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THE UK'S BIGGEST SELLING ASTRONOMY MAGAZINE

Sky at Night

#158 JULY 2018

SUMMER OBSERVING

Solar FLARES

See and image the Sun in detail ***PLUS*** Why flares pose a greater threat to Earth than we thought

Mars up close

View the Red Planet at its brightest since 2003

Deep sky tour

Track down **6** glowing nebulae and star clusters

99 TOP OBSERVING TARGETS... DETAILS INSIDE!

60 years of NASA

What has the space agency achieved since 1958?

WATCH THE SKY AT NIGHT

The latest in the mission to 3D map the Milky Way

MEET THE MEN WHO MAKE STARS

Recreating stellar conditions on Earth

READERS' SOLAR PHOTOS

The best images of our host star sent in by you

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Sky at Night MAGAZINE REVIEWED IN ISSUE 112 SEPTEMBER 2014 ★★★★★

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This month's contributors include...

Shaoni Bhattacharya
Science writer

With NASA looking for commercial partners, Shaoni discovers how SpaceX's and Boeing's bids are shaping up. *Page 42*

Marcus Chown
Writer and broadcaster

Marcus reveals why we should be more worried about coronal mass ejections than meteor strikes. *Page 30*

Libby Jackson
Science author

As a specialist writer in spaceflight, Libby is the perfect host for our celebration of 60 years of NASA. *Page 64*

Stephen Tonkin
Binocular astronomer

Even against a backdrop as dense as the southern Milky Way, Stephen finds spectacular sights for binocular users to savour. *Page 58*

Welcome

Here comes the Sun, so embrace its observing opportunities

Last month we had the summer solstice in the northern hemisphere, but this month the whole planet marks another important date of the summer season: aphelion day. On 6 July, Earth reaches the furthest point in its orbit from the Sun. Turn to page 51 to discover what impact the extra 5 million km distance between us and our star will have.

What better way to celebrate than by taking the chance to observe the Sun? On page 78, Pete Lawrence guides you through the detail you can see on the Sun's disc and the best equipment to reveal it in safety.

Despite the short nights, there's still loads to observe this month – with Mars at its brightest and largest since 2003 (though frustratingly low to the horizon for UK observers) and a total eclipse of the Moon. More on these events and other top picks for July in the Sky Guide, starting on page 47.

Staying with the Sun, on page 30 Marcus Chown looks at research into exoplanets and their host stars which suggests that many G-type stars, like our Sun, are wildly more unstable than previously thought. They exhibit immense outbursts of radiation more damaging than the largest yet recorded on Earth with perturbing regularity.

It is perhaps timely, then, that this month sees the launch of the Parker Solar Probe, a mission that will travel closer to the Sun than any other before it. News editor Elizabeth Pearson reveals how its data will increase our knowledge of the ferocious solar processes on page 37.

Enjoy the issue!

Chris Bramley Editor

PS Our next issue goes on sale 19 August.

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C = on the cover

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Get started with The Guide on page 78 and our online glossary at www.skyatnightmagazine.com/dictionary

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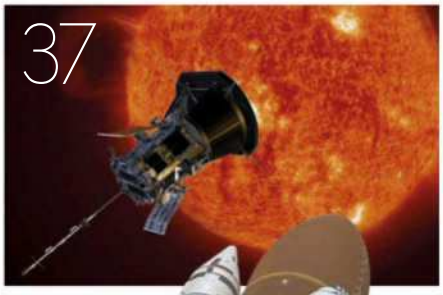
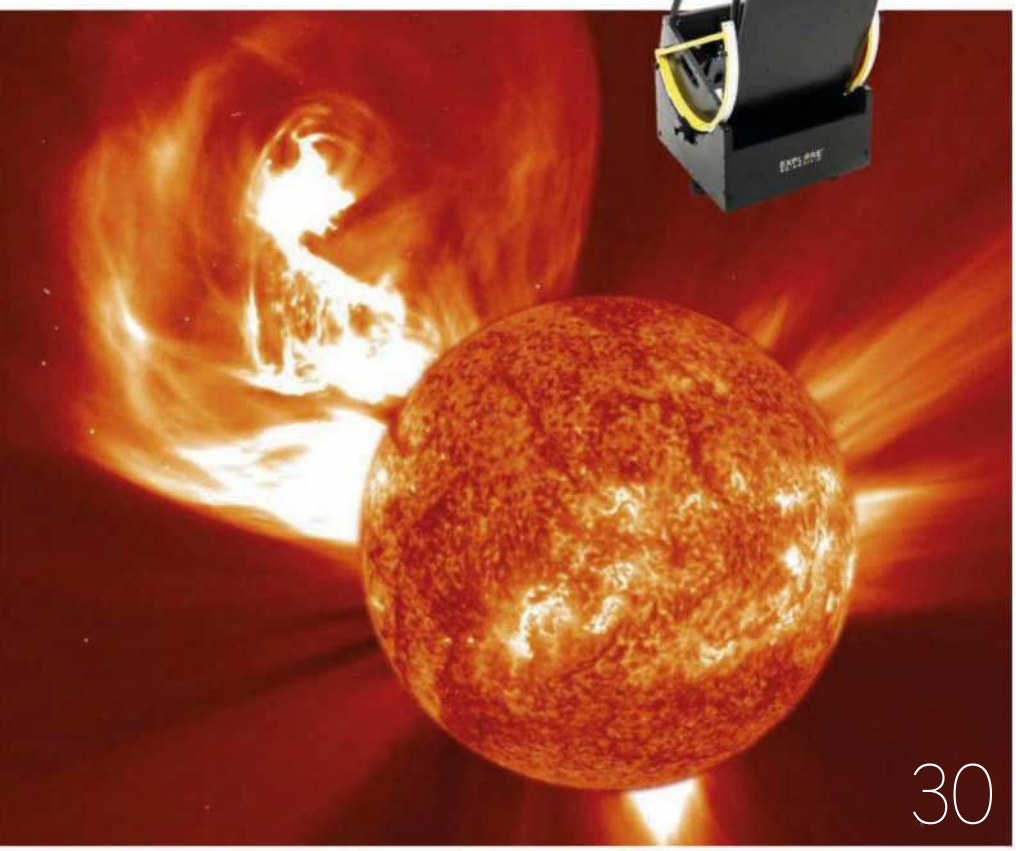




Regulars

JULY'S BONUS CONTENT

HOW TO FIND IT

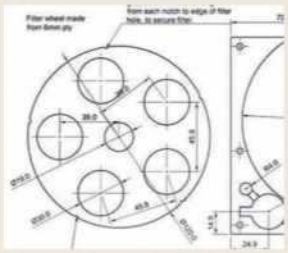
Visit **www.skyatnightmagazine.com/bonuscontent**, select July's bonus content from the list and enter the authorisation code **DT9JFVB** when prompted

THERE'S MORE ONLINE

July highlights

Watch *The Sky at Night*

Gaia is a mission to map 1.7 billion stars in the Milky Way, providing a picture of the past, present and future of our Galaxy. Following its second data release, Maggie and Chris look at some of the most significant revelations from the mission so far, while Pete Lawrence reveals how best to view the Milky Way during the summer months.



How to build a 1.25-inch filter wheel

Download plans, diagrams and additional images to help with this month's *How To* project on page 80.

Creating stars in the New Mexican desert

We speak to the scientists recreating stellar conditions in the lab in order to study white dwarves up close.

Sneak preview: The Order of Time

A chapter of physicist Carlo Rovelli's new book, in PDF and audiobook narrated by actor Benedict Cumberbatch.

And much more...

- ▷ **Hotshots gallery**
- ▷ **Eye on the sky**
- ▷ **Extra EQMOD files**
- ▷ **Binocular tour**
- ▷ **Equipment review guide**
- ▷ **Desktop wallpaper**
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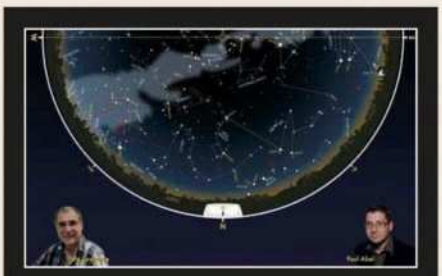

EVERY MONTH

Virtual Planetarium

With Paul Abel and Pete Lawrence

Explore July's night-sky highlights with Paul and Pete.

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YOUR BONUS CONTENT

A gallery of these and more stunning space images

Uncovering the ultraviolet Universe

A view of a spectacular spiral in ultraviolet and optical light helps astronomers learn more about how stars are born

HUBBLE SPACE TELESCOPE, 17 MAY 2018

Spiral galaxy Messier 96 is just one of 50 local galaxies being analysed by astronomers as part of LEGUS (Legacy ExtraGalactic UV Survey), a study that seeks to unlock the secrets of star formation. Viewing these star-forming galaxies in ultraviolet light helps astronomers track young, hot stars so they can focus on the processes that stars undergo just after birth.

The scope of the survey should enable astronomers to get a thorough picture of stellar formation: it contains about 8,000 star clusters and 39 million individual stars at least five times more massive than the Sun.

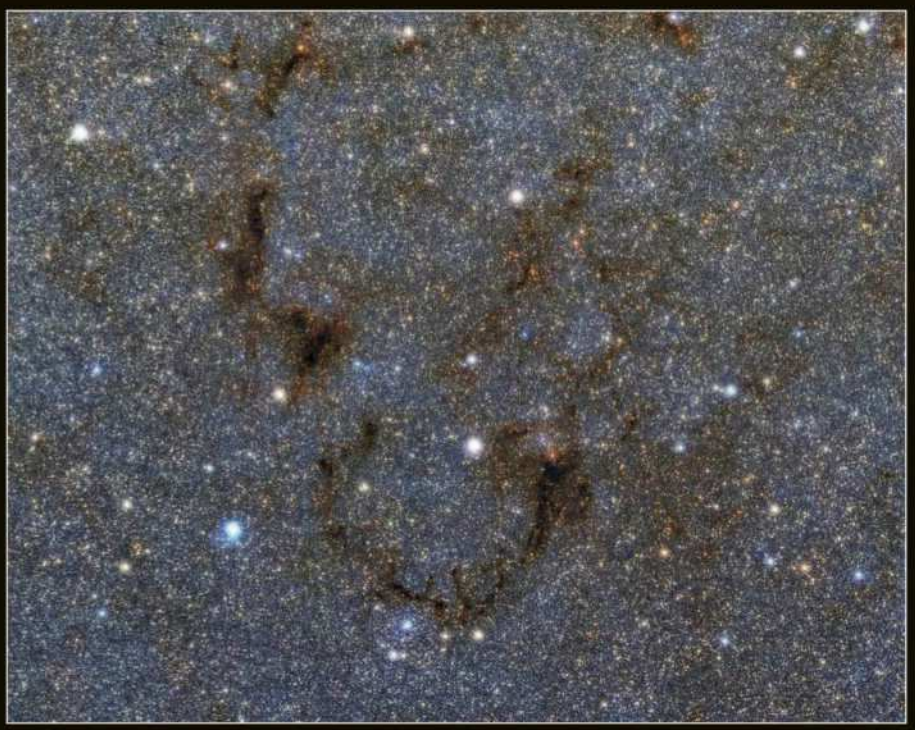
Messier 96 is about 35 million lightyears from Earth and is about the same mass as the Milky Way. Stars are being born within the dark filaments in the spiral arms, and these youngsters glow bright pink as they shine through surrounding hydrogen gas.

NASA/ESA AND THE LEGUS TEAM

▲ A farewell embrace

VERY LARGE TELESCOPE, 21 MAY 2018

Just released by ESO, this image was taken by the VIMOS spectrograph on the Very Large Telescope just before it was decommissioned in March. It is a fitting final image, as VIMOS data is helping astronomers learn more about the lives of galaxies. These two spirals are colliding with each other 110 million lightyears away to form a single object, named Arp 271.

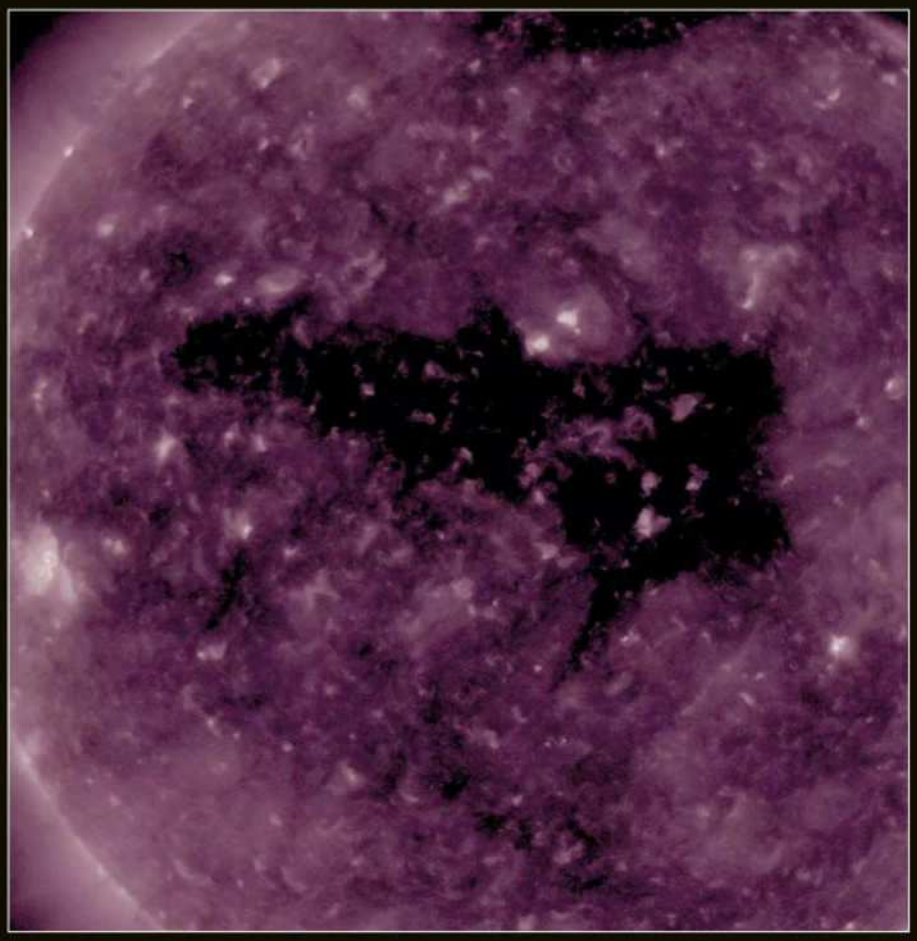


Dusty dark clouds ▶

VISTA TELESCOPE, 30 APRIL 2018

There was a time when astronomers thought dark patches in a starry scene were simply an absence of stars. Now we know that these are dark nebulae: a form of dusty cosmic cloud that blots out starlight. Even the infrared capabilities of the VISTA telescope cannot see through these dark patches, located in the sky close to the Lagoon Nebula (not pictured).

ESO/JUAN CARLOS MUÑOZ, ESO/VVV SURVEY/D. MINNITI, SOLAR DYNAMICS OBSERVATORY/NASA, NASA/ESA AND THE LEGUS TEAM



◀ Hole in the solar surface

NASA SOLAR DYNAMICS OBSERVATORY, 2-4 MAY 2018

This huge dark coronal hole stretches roughly halfway across the solar disc. These features are caused by open magnetic field lines, which release charged particles called solar winds into space. Because they are less dense and cooler, they appear darker in ultraviolet images such as this.

▼ Fruitful encounter?

HUBBLE SPACE TELESCOPE, 17 MAY 2018

In the bottom right of this image of dwarf galaxy UGC 5340, the blobs of bright colour indicate a pocket of star formation. Often, bursts of star formation occur as galaxies interact with each other, the gravitational forces whipping up cosmic dust and beginning the process afresh. Astronomers believe this may have been the case with UGC 5340.

Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS CUTTING EDGE

Our experts examine the hottest new astronomy research papers

COMMENT

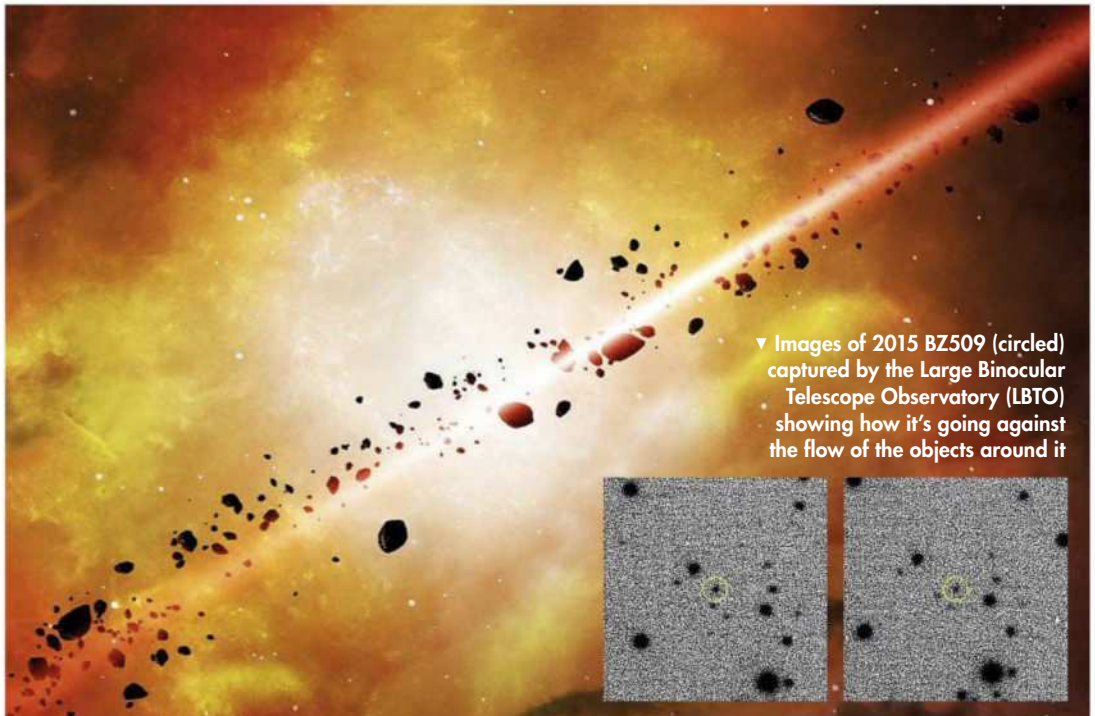
by Chris Lintott

The story of the Solar System is recorded in its small bodies, which is why there is such excitement about New Horizons' upcoming encounter with 'Ultima Thule' in the Kuiper Belt. BZ509's unique orbit suggests it has a similarly fascinating story to tell.

That doesn't mean it's necessarily interstellar. This recent study uses simulations that merely show its current orbit has been stable over billions of years, and so it's reasonable to assume it's been there since our Solar System was forming.

The team argues that this ancient history makes an interstellar origin likely, but I'd bet that maybe BZ509 just got lucky, finding the perfect conditions for this weird orbit. There might be other smaller bodies following similar paths that we just haven't seen yet. Further study of this fascinating object will reveal who is right, but it may tell us more about our home system than revealing some distant origins.

CHRIS LINTOTT co-presents *The Sky at Night*



▼ Images of 2015 BZ509 (circled) captured by the Large Binocular Telescope Observatory (LBTO) showing how it's going against the flow of the objects around it

Interstellar immigrant found in outer Solar System

Asteroid may hold clues about what life could be like around other stars

An asteroid in the outer Solar System may have been born around another star before emigrating to our Solar System 4.5 billion years ago, it has recently been determined. The extrasolar origins of asteroid 2015 BZ509 became apparent when astronomers discovered that although its orbit crosses that of Jupiter, it is moving in the opposite – or retrograde – direction.

"How the asteroid came to move in this way while sharing Jupiter's orbit has until now been a mystery," says Fathi Namouni from the Observatoire de la Côte d'Azur, who led the study. "If 2015 BZ509 were a native of our system, it should have had the same original direction as all of the other planets and asteroids, inherited from the cloud of gas and dust that formed them."

Instead it's thought that the asteroid could have originated around one of the other stars that was born alongside the Sun in the same stellar nursery, which means they would have once been much closer neighbours.

"The close proximity of the stars, aided by the gravitational forces of the planets, helped these systems attract, remove and capture asteroids from one another," says Helena Morais from São Paulo State University who also took part in the study.

Astronomers will now study the asteroid to understand the composition of the rock to see if it began around a distant star. They can take their time, however, as the asteroid is in a stable orbit around the Sun, unlike our previous interstellar visitor spotted in 2017, 'Oumuamua, which sped past the Sun and beyond the reach of Earth's telescopes within a few months of first being detected.

▸ See Comment, left

skyatnightmagazine.com 2018

Where the skies are always clear

Planetary scientists have found every amateur astronomer's dream planet: a cloudless world. Sadly, WASP-96b is also a hot Saturn, with temperatures reaching around 1,000°C, making it a less than ideal spot for stargazing.

The team observing WASP-96b detected a full spectrum of the element sodium, which is only possible because the planet has few or no clouds blocking out parts of the light. These clear skies will allow the researchers to look right through the exoplanet's atmosphere, rather than being blocked by the cloud layer. A study of the exoplanet's full atmospheric composition will help in understanding its geoclimactic history.

"It's difficult to predict which of these hot atmospheres will have thick clouds. By seeing the full range of possible atmospheres, from very cloudy to nearly cloud-free, we'll gain a better insight into what these clouds are made of," says Jonathan J Fortney from the University of California, Santa Cruz.

https://wasp-planets.net

▲ Clear skies are enabling scientists to look deeper into WASP-96b

Did Galileo detect a plume?

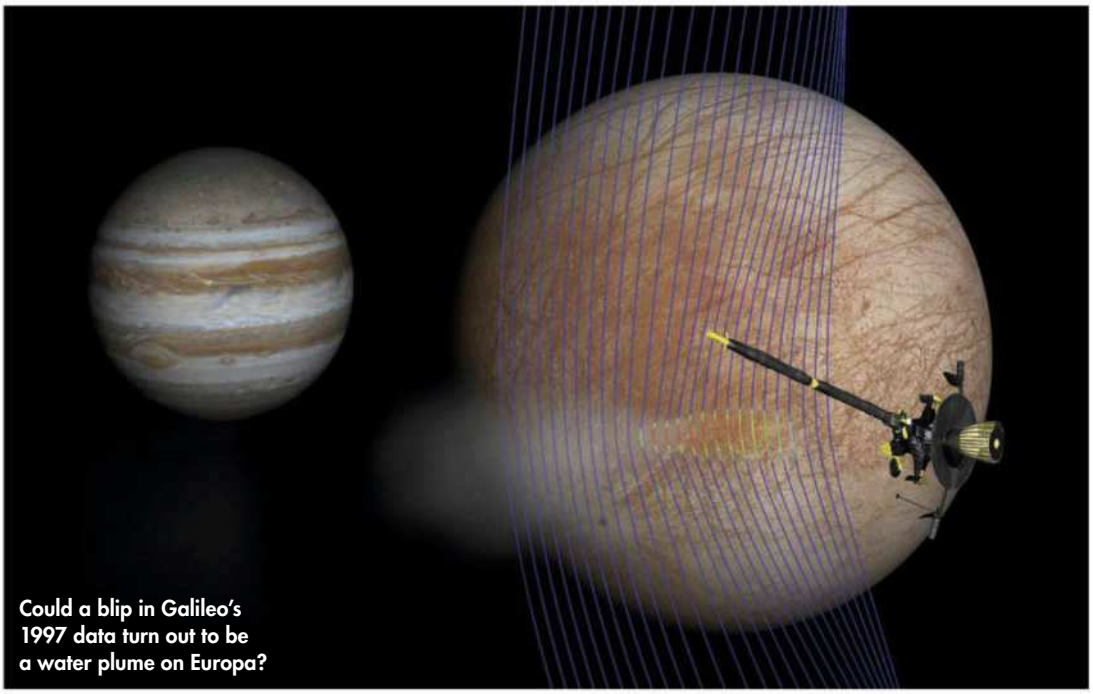
Find lends more weight to theory that Jupiter's ice moon has water jets

A fresh look at old data from the Galileo spacecraft, which orbited Jupiter from 1995 to 2003, has revealed that the probe might have grazed past a water plume from icy moon Europa.

Astronomers decided to re-examine Galileo's data after realising it covered an area where plumes are thought to be erupting today. They found that when Galileo passed over the region in 1997, it detected a brief warp in the moon's magnetic field. We won't know whether Europa has water jets for certain until a new spacecraft bound for the moon, Europa Clipper, arrives in the 2020s to look for them directly.

"If plumes exist and we can directly sample what's coming from the interior of Europa, then we can more easily get at whether Europa has the ingredients for life," says Robert Pappalardo, Europa Clipper's project scientist.

solarsystem.nasa.gov/missions/galileo



Could a blip in Galileo's 1997 data turn out to be a water plume on Europa?

NEWS IN **BRIEF**

GLUTTONOUS BLACK HOLE

The fastest-growing black hole ever has been found by the Sky Mapper telescope. As the monster sucks down the mass of our Sun every two days, the turmoil makes gas surrounding it start to glow. "If we had this monster sitting at the centre of our Milky Way, it would appear 10 times brighter than the full Moon… an incredibly bright pin-point star that would almost wash out all of the stars in the sky," says Christian Wolf from the Australian National University.

INVESTMENT IN UK SPACE COMS

Goonhilly Earth Station in Cornwall, which provides spacecraft tracking and monitoring services to some of the world's largest satellite operators, has received a £24 million donation from UK businessman Peter Hargreaves. The station has already joined the Deep Space communications network, the first private operator to do so, and this investment will help it grow even further. The funding injection is particularly well timed, as Cornwall is one of the potential sites for a future UK spaceport.

NEWS IN BRIEF

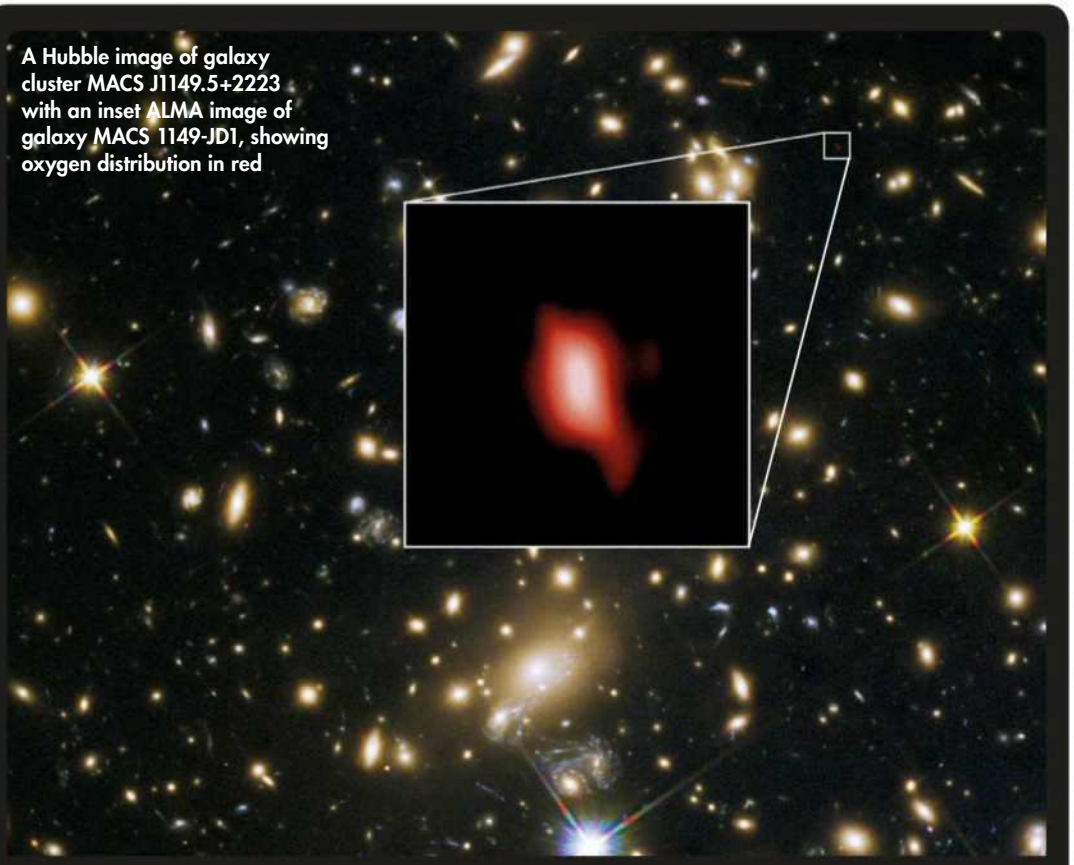
JUNO MISSION EXTENDED

NASA's Jupiter mission, Juno, has been extended for another three years. Originally, Juno was to be crashed into the planet in July to protect the potentially habitable icy moons from contamination. However, trouble with the engines meant Juno has only done 14 of the 32 planetary flybys planned for the primary mission. The extension will allow Juno to finish its task. There's potential to extend this deadline again, depending on how well Juno continues to withstand Jupiter's radiation.

CHANG'E 4 RELAY LAUNCHED

On 21 May the China National Space Administration launched a relay satellite that will help the agency land and operate Chang'e 4, the first probe to land on the far side of the Moon. The relay is needed to pass communications between Chang'e 4 and Earth, as the Moon blocks direct contact. The relay satellite is currently in a gravitationally stable spot 65,000km behind the Moon, called the second Lagrange point.

NASA/JPL-CALTECH, RADBOUD RADIO LAB, ALMA (ESO/NAOJ/NRAO), NASA/ESA HUBBLE SPACE TELESCOPE/W. ZHENG (JHU) M. POSTMAN (STSCI) THE CLASH TEAM/HASHIMOTO ET AL



A Hubble image of galaxy cluster MACS J1149.5+2223 with an inset ALMA image of galaxy MACS 1149-JD1, showing oxygen distribution in red

Oxygen helps to date the EARLIEST STARS

Discovery of distant oxygen could help trace ancient stellar history

Astronomers have detected oxygen further away than ever before, a find which could help date the birth of the first stars. Researchers using new measurements taken by the Atacama Large Millimeter/submillimeter Array (ALMA) found oxygen in MACS 1149-JD1, a galaxy so distant its light takes 13.3 billion years to reach us.

"I was thrilled to see the signal of the distant oxygen in the ALMA data," says Takuya Hashimoto from Osaka Sangyo University. "This detection pushes back the frontiers of the observable Universe."

Because the light has taken so long to reach us, we see the galaxy as it was just 500 million years after the Big Bang. And it is this youthfulness that makes the discovery of oxygen so remarkable, as the element can only be created via fusion in the heart of a star. This means that just 500 million years after the Big Bang MAC S1149-JD1 must have already had a generation of stars which created oxygen and then died, releasing the element into the galaxy.

"This galaxy is seen at a time when the Universe was only 500 million years old and yet it already has a population of mature stars," says Dr Nicolas Laporte from UCL, who helped with the study. "We are therefore able to use this galaxy to probe into an earlier, completely uncharted, period of cosmic history."

In order to look back even further into the galaxy's past, the team measured its infrared brightness, a gauge of how long the stars have been heating it up. Using data from the Hubble and Spitzer space telescopes, the team has calculated that the first stars must have burst into life a mere 250 million years after the Universe began.

"Determining when the cosmic dawn occurred is akin to the Holy Grail of cosmology and galaxy formation. With these new observations of MAC S1149-JD1 we are getting closer to directly witnessing the birth of starlight. Since we are all made of processed stellar material, this is really finding our own origins," says Professor Richard Ellis from the University College London, who co-authored the study.

http://www.almaobservatory.org/

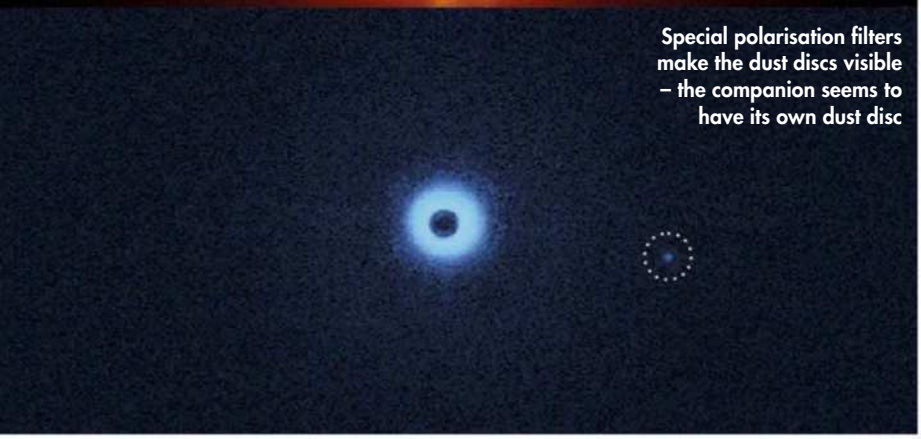
CUTTING EDGE

Our experts examine the hottest new research

Is it planet? Is it a star?

Something is growing around a distant star. But what exactly is it growing into?

An infrared image of CS Cha captured by the Very Large Telescope in Chile. The newly discovered companion is highlighted



Special polarisation filters make the dust discs visible – the companion seems to have its own dust disc

C. GINSKI & SPHERE X 2

New observations of a star system in the southern constellation of Chamaeleon, CS Cha, have revealed what seems to be a planet-sized object in the process of forming. The new object, captured in data from the Very Large Telescope (VLT), is one of a small class of such bodies which lie a long way out from their companion stars, making them easier to image but difficult to explain.

This new object, which is about 600 lightyears away, is situated over 30 billion km from CS Cha itself – that's seven times further out than Neptune is from the Sun. It was first spotted in a survey carried out by the VLT back in 2006, and so by now we can be certain that, despite the great distance involved, it really is a true member of the system, gravitationally bound to its primary. CS Cha is a young double star, and it's surrounded by what seems to be exactly the kind of disc of gas and dust from which planets form.

So what's the problem? By the time you get as far out as the companion we see, the density of dust in the disc will be so low that planet formation would take a long time – much longer than the lifetime of the star to date. In fact, the observations show the disc only reaches three-quarters of the way.

The companion doesn't seem simple, either. The team that studied it, led by astronomers from Leiden in the Netherlands, tried to make sense of what it was seeing using a variety of theoretical models to predict how brightly different planets might shine at different wavelengths, but nothing seems a great fit. There's something more complicated going on.

A clue comes from observations of polarised light, a technique that reveals whether light has been scattered off dust before reaching the observer. We'd expect some scattering from the disc of dust around the main star, but the signals are distinct, suggesting that the companion itself is surrounded by its own disc or envelope of dust; in other words whatever it is it is still assembling.

> "Observing the object's movements over the past 11 years, the team has worked out the eccentricity of its orbit, and it's *very* eccentric"

I'm reluctant to call it a planet. The best fit to the data is for an object which about 20 times the mass of Jupiter, right around the value that would make something a small brown dwarf star or a large planet. Either way, it's thrilling to see it still in the midst of assembly. And there's more.

Observing the object's movements over the past 11 years, the team has worked out the eccentricity of its orbit, and it's *very* eccentric. It has an orbit less circular than Pluto's! That makes formation from the main disc – where all the dust is in roughly circular orbits – very unlikely, while a history rather like that of a star, which collapses directly from the surrounding gas and dust, much more probable. This unique object may thus be telling us that all of the distant companions imaged over the last 10 years – amongst the most intriguing of planet and planet-like discoveries – formed in this way.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project

CHRIS LINTOTT was reading… *First direct detection of a polarized companion outside of a resolved circumbinary disk around CS Cha* by C Ginski et al. **Read it online at https://arxiv.org/abs/1805.02261**

NEWS IN BRIEF

OUR SUN'S NEBULAR FATE?

The Sun will produce a planetary nebula just like Abell 39 (pictured above) when it dies, according to the latest models of stellar life cycles. Astronomers know that at the end of our star's life it will transform first into a red giant before becoming a white dwarf. What wasn't certain, though, was whether it would leave behind a halo of gas and dust – a planetary nebula – but these latest simulations reveal that the Sun is one of the smallest types of star that can create a nebula.

ASTEROID IN KUIPER BELT

An asteroid has been found in exile in the Kuiper belt. A recent study of the object 2004 EW95 found it was rocky, meaning it probably originated in the asteroid belt but was later thrown out into the Kuiper belt. "Given 2004 EW95's present abode in the icy outer reaches of the Solar System, this implies it has been flung out into its present orbit by a migratory planet in the early days of the Solar System," says Tom Seccull of Queen's University Belfast, who led the study.

WIYN/NOAO/NSF, ESO/M. KORNMESSER, ZUMA PRESS INC./ALAMY STOCK PHOTO, NASA, NASA/JHUAPL/SWRI, HUBBLE SPACE TELESCOPE COMET TEAM AND NASA/ESA

Moonwalker Alan Bean dies, aged 86

The astronaut who transformed his lunar experiences into art

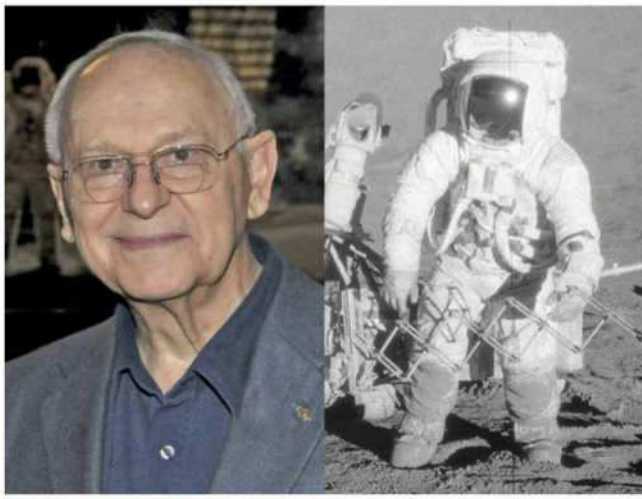
Alan Bean, the fourth person to walk on the Moon, died on 26 May at the age of 86.

Bean flew on the Apollo 12 mission in November 1969. Of Scottish descent on his father's side, he carried a piece of MacBean tartan with him. He returned to space four years later to work on the Skylab space station.

Bean retired from NASA in 1981 to become an artist, painting dozens of works depicting the Apollo missions, several of which were infused with lunar dust from his own mission patch.

"He was a one-of-a-kind combination of technical achievement as an astronaut and artistic achievement as a painter," says astronaut and friend Mike Massimino. "What was truly extraordinary was his deep caring for others and his willingness to inspire and teach by sharing his personal journey so openly."

www.alanbean.com



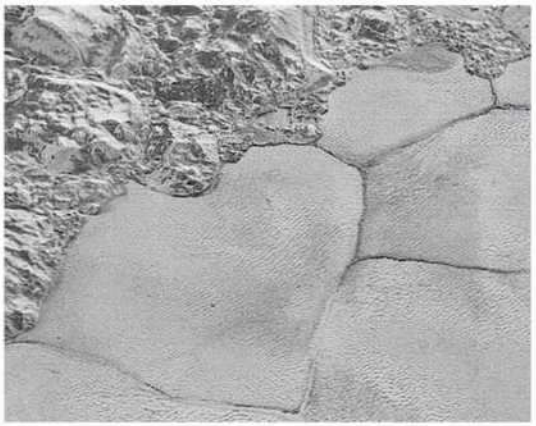
▲ Alan Bean on Earth, and on the Moon, a monochrome world he saw with an artist's eye, John Glenn once said

Dunes on Pluto are surprisingly recent

Dunes made of methane have been spotted on Pluto. A new study of images taken by the New Horizons probe in 2015 found a large field of the methane dunes on the boundary between a nitrogen glacier called Sputnik Planitia and the Al Idrisi Montes mountain range. Researchers believe it could have formed as recently as 500,000 years ago, suggesting the surface geology of Pluto is much more active than previously thought.

"It turns out that even though there is so little atmosphere, and the surface temperature is around –230°C, we still get dunes forming. It is another piece of the jigsaw in making sense of this diverse and remote body," says Matt Telfer from the University of Plymouth, who led the study.

http://pluto.jhuapl.edu



▲ The mountain range on the edge of the Sputnik Planitia ice plain, on which you can see dune formations

LOOKING BACK THE SKY AT NIGHT 31 July 1994

On 31 July 1994 Patrick and *The Sky at Night* looked towards the largest planet in our Solar System and its recent visitor, Comet Shoemaker-Levy 9.

The comet was discovered on 24 March 1993 by husband-and-wife astronomers Carolyn and Eugene M Shoemaker, and David Levy. It quickly became apparent that this was no ordinary comet. Not only was it orbiting Jupiter rather than the Sun, it seemed that a recent close pass with the planet had torn it apart into fragments. On 16 July 1994, the first of these pieces ploughed into Jupiter's atmosphere.

Over the next week, the world's ground and space telescopes watched as pieces of the comet thudded into Jupiter's southern hemisphere until the final piece impacted on 22 July. However, the scars left by the comet – a string of dark brown spots staining the planet's clouds – remained for months afterwards.

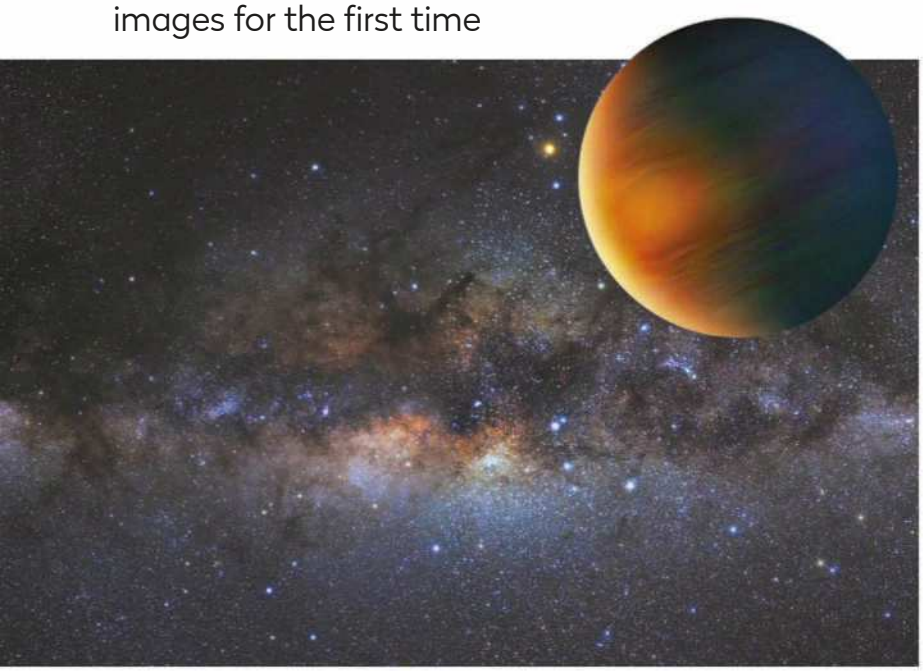
▲ The scars left on Jupiter by the impact of Comet Shoemaker-Levy 9

CUTTING EDGE

Our experts examine the hottest new research

Exoplanet hunt a success for amateur astronomers

A hot Jupiter has been discovered using amateur images for the first time



THINKSTOCK, ESA/NASA/G. TINETTI (UNIVERSITY COLLEGE LONDON UK & ESA) AND M. KORNMESSER (ESA/HUBBLE)

Over recent years there has been a growing trend for amateur astronomers becoming involved in 'professional' research, including the rapidly emerging field of exoplanet discovery. This has included Chris Lintott's own Zooniverse projects, such as Planet Hunters and Exoplanet Explorers. Many of these projects, however, have focused on the search for planets in data sets already created by professional astronomers. Now, Artem Burdanov at the Space sciences, Technologies and Astrophysics Research (STAR) Institute in the University of Liège, Belgium, and his colleagues report on an exciting new initiative for amateur astronomers discovering new exoplanets from their own images, using readily available and relatively affordable equipment.

The Kourovka Planet Search (KPS) project uses wide-field telescopic images gathered by an amateur astronomer and searches for previously unknown exoplanets using the transit method (whereby an orbiting exoplanet is detected by the periodic dimming of the starlight as it passes across the disc of its sun as seen from our perspective). And KPS has now discovered its first new exoplanet, KPS-1b. This world is a 'hot Jupiter', almost exactly the same mass and diameter as Jupiter but in a very close orbit of only 1.7 days around its K1-type star. This new exoplanet has now been characterised by follow-up observations with larger telescopes.

▲ Despite the galactic plane being so densely packed with stars, amateur astronomers are finding exoplanets there

LEWIS DARTNELL is an astrobiology researcher at the University of Westminster and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

What's particularly interesting about this result is that the survey is focusing on a region most professional exoplanet searches deliberately avoid – the galactic plane. While the plane has a huge number of stars to observe, the area presents several problems for detecting exoplanets unless the telescope system has a high enough spatial resolution. The star-crowded region of the galactic plane can make spotting transiting planets harder because the blending of light from several stars can dilute the brightness-dip signal from a planet around one of them, and eclipsing binary stars can also trigger lots of false-alarm detections.

The KPS project, however, has been specifically designed to offer not only a wide-field, but also a significantly higher spatial resolution than even several professional surveys. All this means that this amateur effort is able to discover hot Jupiters lurking within the galactic plane that other observing activities can't. Although hot Jupiters are relatively rare – they exist around only about 1 per cent of the stars in the solar neighbourhood – they offer attractive targets for ground-based planet-hunting efforts. Hot Jupiters are much more likely to transit as they orbit so closely to their sun; their short orbital period maximises the number of starlight-dips that are needed for a confident detection; and their large size gives a more conspicuous transit signal (they block more of their star's light) for measuring with ground-based telescopes.

> "Although hot Jupiters are relatively rare they offer attractive targets for ground-based planet-hunting efforts"

Now the astronomers involved are building on the success of KPS, applying the lessons they've learned to launch the Galactic Plane eXoplanet (GPX) survey. They aim to gather around 150 hours of data from many stars over a three-month period, all targeting the largely overlooked region of the sky along the galactic plane. This certainly is a thrilling time for ground-breaking amateur astronomy!

LEWIS DARTNELL was reading… *KPS 1-B – The first transiting exoplanet discovered using an amateur wide-field CCD data* by Artem Burdanov et al
Read it online at https://arxiv.org/abs/1804.05551

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What's on

Our pick of the best events from around the UK

Bluedot 2018

Jodrell Bank Observatory, Cheshire, 20-22 July 2018

The Bluedot festival returns to the beautiful Cheshire countryside for four days of music, science and comedy at the historic Jodrell Bank Observatory. Under the shadow of the famous Lovell Telescope, this year's musical headliners will include the likes of Flaming Lips, Future Islands, The Chemical Brothers, Gary Numan and The Orb.

As well live music, festival-goers this year can expect enthralling science talks from big names such as Richard Dawkins, Jim Al-Khalili, Monica Grady, Tim O'Brien, Dallas Campbell and Libby Jackson. Talks, demos and lectures will look at the rise of robots, the study of space rocks, explosions on the Sun, black holes, the Big Bang, the Space Race and the upcoming James Webb Space Telescope.

The festival also includes camping, sci-fi film screenings, street food stalls and pop-up craft beer pubs, with plenty to keep young ones occupied and late-night entertainment for those seeking a full-on festival experience. The grounds of Jodrell Bank feature interactive exhibitions, a Galaxy Garden, a portable planetarium and artistic installations, so there is a lot of family-friendly fun to explore away from the hubbub of the main music stages.

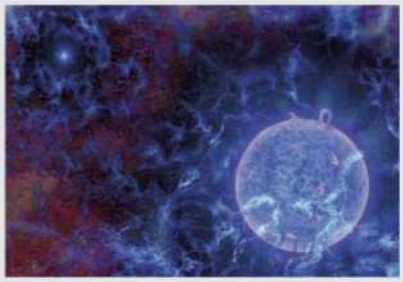
For the full 2018 line-up and more information on tickets and camping, visit the Bluedot website.

www.discoverthebluedot.com

BEHIND THE SCENES

THE SKY AT NIGHT IN JULY

BBC Four, **8 July,** 10pm (first repeat BBC Four, **12 July,** 7.30pm)*



The early Universe was dark for millions of years until the first stars burst into life

OUTBACK ASTRONOMY

Earlier this year, news broke that astronomers had seen the Cosmic Dawn: the moment the first stars formed. This month, Chris travels to the Murchison Radio-astronomy Observatory to find out how the discovery was made, and what else these extraordinary telescopes can tell us about the Universe.

**Check www.bbc.co.uk/skyatnight for subsequent repeat times*

Astrophotography exhibition

Royal Observatory Greenwich, until 22 July, 10am – 5pm

This month is the last chance to see the winning images from the Insight Investment Astronomy Photographer of the Year 2017 competition. Visit this free exhibition for a look at the top astrophotos as selected by last year's panel of judges, featuring nebulae and galaxies, the planets, the Sun, the Moon, nightscapes and beautiful aurorae. The exhibition is open every day until the closing date.

www.rmg.co.uk/royal-observatory/insight-astronomy-photographer-year

An evening with Aberdeen AS

The Bettridge Centre, Newtonhill, Aberdeenshire, 24 July, 7pm

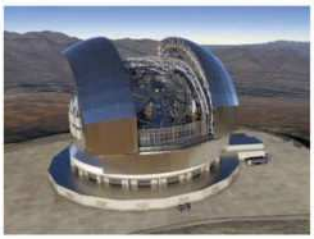
Aberdeen Astronomical Society

Join Aberdeen Astronomical Society for one of its regular monthly meet-ups. While bright summer evenings in the north of Scotland are not especially suited to stargazing, this is the perfect opportunity to meet seasoned amateur astronomers, discuss the latest astro news and get help and advice with your observing. This session is free and open to all, but check it is going ahead before travelling. Contact info is available at the society's website.

www.aberdeenastro.org.uk

Mega mirrors

Royal Observatory Edinburgh, 12-13 July



Head to the Royal Observatory and hear about the upcoming Extremely Large Telescope currently being built in Chile's Atacama Desert, which will boast a mammoth mirror 39m across. Plus, create your own mirrored masterpiece using super shiny materials. An adults-only version of this event is occurring on 12 July at 7.30pm, while a child-friendly session will take place on 13 July at 2pm. Tickets are £5 or £4 concessions.

www.roe.ac.uk

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the web page.

BLUEDOT X 4, ROYAL OBSERVATORY GREENWICH, ABERDEEN ASTRONOMICAL SOCIETY, ESO/L. CALÇADA/ACE CONSORTIUM, N.R.FULLER/NATIONAL SCIENCE FOUNDATION

Celebrating the 50th Anniversary of '2001: A Space Odyssey'

2018 is the 50th anniversary of Stanley Kubrick's **2001: A Space Odyssey;** the Isle of Man Post Office has released a series of eight hi-tech stamps that celebrate half a century since the making of this iconic British film, rated one of the greatest films of all time.

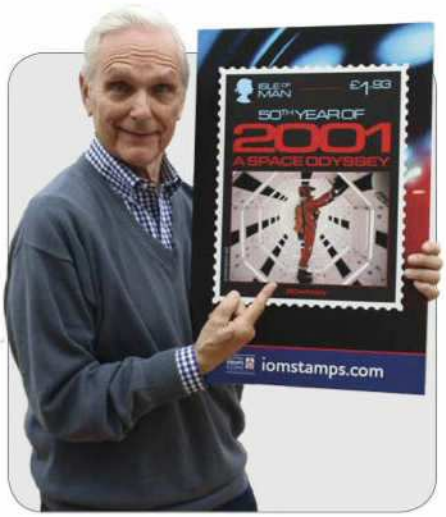
For any of us who have gazed at the stars and wondered whether we are alone, whether we are the first, whether we have a future beyond our nearest star, the film was and still is, a mind-blowing journey through possibilities that most of us cannot comprehend. Arthur C. Clarke mused. "If you understand 2001 completely, we failed. We wanted to raise far more questions than we answered."

The film was made in England, mostly at Borehamwood Studios and is prescient in its imagination of future technology; one of the crew watches BBC 12 News on a tablet computer, the AI is conversational and manages lip-reading - something our AIs today have only just achieved. The film was released a year before the moon-landing and yet its depiction of life in space would not look incorrect now. It truly is a masterpiece of science fiction.

The Isle of Man has a long connection with space research, travel and communications and is home to many space related companies, so there is no surprise that their Post Office (part of the Government) chose to mark this important milestone. Chris Stott, who has been influential in the space industry met Arthur C. Clarke in Sri Lanka in the 1990s and it was Clarke who encouraged Chris to set up his satellite company ManSat and essentially launch the Isle of Man Space Industry. Chris heads up the island chapter of the International Space University of which Arthur C. Clarke was President.

Designed by London creative agency Glazier Design, whose clients included Professor Stephen Hawking, the series of eight stamps depict some of the most iconic imagery from the film; Kubrick himself, author Arthur C. Clarke from whose short story the film was adapted, the 'Monolith', Star Child, Dr. Dave Bowman and, of course, the HAL 9000, the errant AI. In true Kubrick style, each of the 2001 stamps contain hidden secrets for fans to find. The special First Day and Commemorative Covers are a ground-breaking homage to the film and much of the collection is in strictly limited-edition numbers, highly prized by collectors and film fans.

Buy the stamps online at www.iompost.com/2001



"What a beautiful way to celebrate this film & a man whose imagination soared in the films that he made. Save your stamps or send them soaring."

Keir Dullea (Dr Dave Bowman)

WIN!

Win much sought after 2001: A Space Odyssey Printer's Pane number 2, worth £500. Email competition@iompost.com and tell us the 8 secrets hidden on the stamps.

Isle of Man STAMPS & COINS

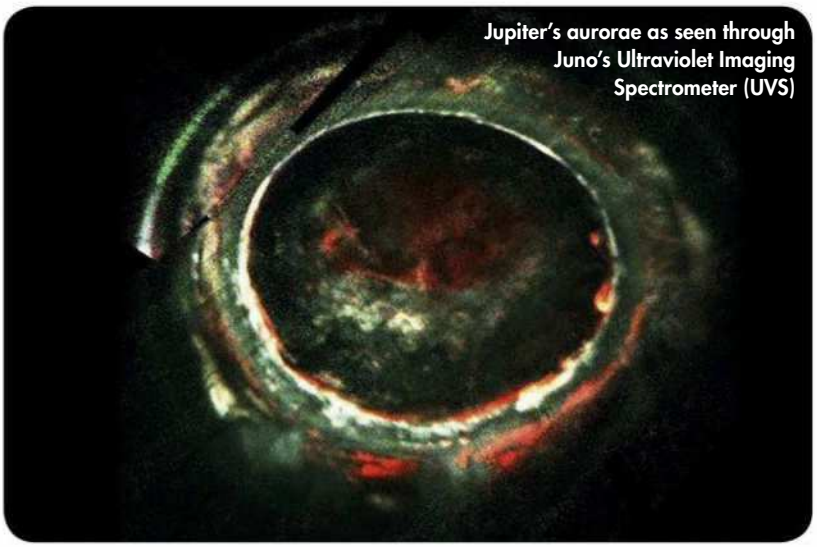
Competition closes September 15th 2018. T&Cs on ***iompost.com/2001***

A PASSION FOR SPACE

with **Dr Fran Bagenal**

Juno is showing us that everything about Jupiter is a bit messier than we expected

Once every 53 days since 15 July 2016, when Juno was inserted into orbit around Jupiter, the spacecraft performs a perijove pass, its closest approach to Jupiter, when it zooms from pole-to-pole over the gas giant, skimming the swirling clouds and ducking under the hazardous radiation belt. These two-hour-long dives deliver a host of new data from the nine scientific instruments on board. JunoCAM wowed us with the first views ever looking directly down on Jupiter's poles, and these images are illustrative of Juno's early discoveries: the closer we look at this planet, the more structure we see.



Jupiter's aurorae as seen through Juno's Ultraviolet Imaging Spectrometer (UVS)

Above about 50° latitude, the planet darkens and takes on a blue tinge. Juno's images show spectacular eddies and a chaotic mass of jostling storms. On every scale, down to the 50km resolution of JunoCAM, we see structure in Jupiter's atmosphere: vortices, thunder clouds, waves and turbulence. In retrospect, we probably shouldn't have been so surprised, since nature across the Universe tends to reveal more structure as we zoom in.

To work out what Jupiter looks like deeper down inside, we need to consider the shape and strength of the planet's gravitational field. Juno maps this by carefully measuring small variations in the planet's motion as it orbits. Its preliminary results reveal that the interior structure of Jupiter does not match the standard model of a planet with distinct layers, sharp boundaries and a solid core of rock and 'ice' (molecules like water and ammonia, though not frozen) at the centre. Instead, Juno's data suggests that things change gradually with depth. Elements heavier than helium mix with the surrounding metallic hydrogen so the core extends roughly halfway up to the surface and with much fuzzier boundaries.

A turbulent nature

My particular interest in Jupiter is its strong magnetic field. This is generated in the electrically-conducting metallic hydrogen region and extends more than 100 times Jupiter's radius out into space, trapping energetic charged particles. Every second, about a ton of volcanic sulphurous gases spew from the atmosphere of the innermost Galilean moon, Io. These gases are ionised by energetic electrons trapped in Jupiter's magnetic field.

The resulting mixture of charged particles – negative electrons plus positive ions of sulphur and oxygen – are measured by Juno's instruments, along with the strong electric and magnetic fields that accelerate the charged particles to high energies. Some of these energetic particles are scattered into Jupiter's atmosphere where they excite bright auroral emissions in the ultraviolet, infrared and radio parts of the spectrum. Yet again, Juno is finding structures in the aurora that are more variable and more turbulent than expected, based on what we experience here on at Earth.

To map out the interior structure, the magnetic field, the atmospheric wind systems, plus the intense aurora, we're extending Juno's mission for at least another three years. Stay tuned as Juno reveals more spectacular detailed structure at every level.

DR FRAN BAGENAL is a co-investigator on the Juno science team

NASA/JPL-CALTECH/SWRI

Quote OMStars

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Credit - Will Gater (willgater.com)

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JON CULSHAW'S

EXOPLANET EXCURSIONS

Jon witnesses a total pulsar eclipse from a planet that's as hard as diamond

Our trip this time takes us 1,200 lightyears from Earth to the constellation of Serpens Cauda, the serpent's tail. Here lies one of those objects that bullies and pushes our notions of the laws of physics to their limit: a spellbinding millisecond pulsar, 1.4 times the mass of the Sun.

It can be hard to focus our sometimes plodding perceptions around these extraordinary objects. Despite being almost 50 per cent more massive than the Sun, this pulsar, PSR J1719-1438, is only 20km in diameter – about the size of Guernsey. PSR J1719-1438 spins at a mind-shredding rate of 10,000 rotations a minute. Astronomical extremes at their most enthralling.

A remarkable planet sits very close to the luminous violence of this parent pulsar. First observed in 2009 using the technique of pulsar timing, planet PSR J1719-1438 b orbits once every two hours at 0.004 astronomical units. It's highly likely to be a carbon world; diamond and crystallised carbon make up a great amount of its composition.

Steering my ship, the Perihelion, to the surface of this extreme object, which is four times the radius of Earth, it feels like a compressed gas giant, compacted into a cosmic-scale diamond. A planet 20 times as dense as Jupiter and only 1.02 times its mass, it's amazing to contemplate how very hard this planet really is! If we ever tried to mine the planet for chunks of its diamond structure, we would need some unfathomably specialist gear; even a light sabre would struggle to cut it out. A less challenging job might be reducing Krakatoa to powder using only a nail file.

Its appearance straddles the border of severity and serenity. Evocative of Metebelis 3, the famous (fictional) blue planet of the Actean Galaxy visited by Jon Pertwee's third Doctor a few times, this world is charged with a sharp, silvered, royal blue glow. It feels like an electric shock made visible.

This alien sky doesn't have a hostile feeling about it; moreover it exudes a sense of caution. It would be all too easy to be captivated by the silvery beauty, but you would be sealing your doom if you idled away too much time on the surface of J1719-1438 b unprotected. Because what you're actually seeing is the monochrome glow of deadly radiation. It's not only a fascinating view that we'd be absorbing! With this in mind, the Perihelion's radiation shields are reinforced and set to maximum.

A beguiling event takes place as a moon of this diamond pulsar planet makes a transit of the parent pulsar. Another first for our exoplanet excursions: a total pulsar eclipse! This one's a black hole in an alien sky, looking like some kind of porthole to a neighbouring universe. Over a planetscape with the appearance of a choppy ocean frozen in time, the pulsar's maddening, flickering light is gracefully interrupted.

With the parent pulsar covered by what's probably a Pluto-sized moon, it looks like an Olympic shot putter has made a night-time, record-breaking throw in front of some remote lighthouse, the action freeze-framed at precisely the perfect moment.

JON CULSHAW is an impressionist, comedian, and guest on *The Sky at Night*

MAIN ILLUSTRATION: MARK GARLICK, SPACECRAFT: PAUL WOOTTON, PHOTO: EMMA SAMMS

Interactive

EMAILS ◢ LETTERS ◢ TWEETS ◢ FACEBOOK

Email us at **inbox@skyatnightmagazine.com**

This month's top prize: four Philip's books

PHILIP'S

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2018 Stargazing*.

Tales from THE EYEPIECE

This month's tale comes from Birmingham Astronomical Society secretary Paul Truelove

One night in the 1980s I was set up at 2am in my garden with a 6-inch reflector, poised for a lunar occultation of Venus. Alone in the dark, I drew a sudden intake of breath as a large warm mass slid along my leg. Jumping away from the eyepiece, I looked down to find next door's cat huddling up to me for some night-time warmth! My surprised reaction caused the feline intruder to scarper into the night. Luckily, the furry incursion didn't mar my pride at having given a talk in the presence of one Sir Patrick Moore earlier that evening. Being a cat lover, Patrick may have appreciated the Venus-feline conjunction. In the image above, I'm pictured with Patrick at Kitt Peak Observatory… or should that be Kitty Peak?

Email your own tales to us at TalesfromtheEyepiece@themoon.co.uk

Stranger things

MESSAGE OF THE MONTH

Reading the article 'Strange Stars' in the June issue I had a bit of a light-bulb moment: if the star SAO 206462 was viewed edge-on it would produce the odd light curve of Tabby's Star. Then I remembered that Tabby's Star is much older and so planetary formation should be much further developed. A little deflated at this error in my thinking I read on, only to have another flash of inspiration: could bulging Vega be the end product of the event developing with binary pair MY Camelopardalis? It's the sign of a good article when it makes you step back and think, and Elizabeth Pearson's article is great! I look forward to more of the same.

The magazine seems to be going from strength to strength with the quality and variety of articles, while still being able to engage the reader with such fascinating topics. Keep up the good work – I haven't missed an issue since #7 so you must be doing something right!

George Futers, Peebles

▲ Our feature on stars that break the rules certainly got some readers thinking

Flattery will get you everywhere, George! It's great to hear that we're providing such a stimulating read. ***– Ed***

Going green

May's Star of the Month article (page 59) was of particular interest to me. I have observed a handful of 'possibly green' stars, including Beta (β) Librae. I've found that detecting green in these stars often depends on the viewer, and comparing results with other observers is great fun. Many of the stars, including Alpha (α) Scorpii and Gamma (γ) Andromedae, are doubles; their contrasting colours often suggest a green tint in one component. Perhaps it's an illusion, but it is fun to compare notes.

Phyllis Lang, Cary, North Carolina, USA

Good to hear the Sky Guide is providing you with tempting targets at the eyepiece, Phyllis. ***– Ed***

The age-old question

In the June issue's Eye On The Sky there is a photo of NGC 6397. The caption states that this globular cluster is 13.4 billion

Tweets

Rhidian Rees
@RhidianR • May 28
Nice clear sky for the International Space Station Big Dipper Flyby @VirtualAstro @butchschlong40 @andy_stones @DavidBflower @skyatnightmag #ISS

SOCIETY in focus

▲ **Hants Astronomical Group shows off its oldest telescope to visitors**

Hampshire Astronomical Group, which is located in the South Downs National Park International Dark Sky Reserve, has a collection of telescopes which we love to show off! Public visits play an important part of our outreach programme, and we welcome all visitors to our open evenings which take place two nights a month from September to March, with our 'Sun Live!' solar observing events in June. The open evenings are very popular, though site constraints limit numbers to about four. If the skies are clear visitors can observe from some of our telescopes including the oldest, a telescope built by Smith, Beck and Beck in the 1860s, and the largest (and newest) telescope, a 24-inch Ritchey-Chrétien reflector. This is also ideal for demonstrating astrophotography.

Volunteer members guide our visitors around the site and the visit is rounded off in the clubhouse with welcoming hot drinks and a presentation on some aspect of astronomy. As a volunteer, it is so satisfying when a visitor sees a planet, the Moon or a deep-sky object for the first time through a telescope. That "Wow!" and the delighted smiles make it all worthwhile.
www.hantsastro.org.uk

Janet Turner, events coordinator, Hampshire Astronomical Group

years old but only 7,800 lightyears away. Surely something this old should be at the farthest reaches of the visible Universe, not outside our cosmic back door! And how was something this close to us (relatively speaking) dated to that age?
Matt Edwards, Lytchett Matravers, Dorset

An interesting question. Most galaxies and clusters are thought to have formed around 13.4 billion years ago, even the ones closer to us. Their ages aren't dependent on their distance from us: our own Milky Way is a venerable 13.5 billion years old! ***– Ed***

It doesn't do it Fermi

The review of Milan Ćirković's book *The Great Silence* in June's issue mentions Fermi's Paradox, which postulates that intelligent life doesn't exist elsewhere in the Universe because if it did they would have already visited Earth. I've always thought that this was a flippant remark, made in a jocular manner to some colleagues during a coffee break and not meant to be taken seriously. Using the same logic one could argue that as we haven't yet visited other stars, intelligent life doesn't exist on Earth.

It would appear that most stars have some sort of planetary debris orbiting around them, so there could potentially be an unbelievable number of planets in the Universe. Say only one in a million is suitable for life, and of those only on one in a million has life evolved, and of those only on one in a million is it intelligent life: you're still left with potentially hundreds of billions of inhabited worlds. Interstellar travel at the moment seems improbable, but intergalactic travel is in the realms of fantasy. Even if a being living in the Andromeda Galaxy did manage the 2.5 million lightyear hop, how would they go about finding Earth out of the other 400 billion solar systems? I truly believe in intelligent life elsewhere in the Universe, but will we ever meet? Sadly I think not.
Brian Beresford, via email

A fascinating reflection, Brian. Even if we never get to communicate, the knowledge that there is intelligent life elsewhere will surely be a discovery greater than when Galileo first observed Jupiter's moons. ***– Ed***

Tweets

Jim richardson
@jimmyrich_2 • May 7
Paid my first visit to pepperbox hill near #salisbury #Wiltshire the other evening to shoot some #startrails with my #xt2 pleased with this one @nationaltrust @Fujifilm_UK @FujifilmEU @_fujilove_ @ThePhotoHour @AP_Magazine @skyatnightmag @BBCStargazing

Meanwhile on FACEBOOK...

WE ASKED: What will you be observing over the coming summer months?

Peter McNulty
I will be observing Saturn and Titan as well as 4 Vesta. DSOs will be varied but Vega and M19 are of interest.

Paul Scott
In July I travel back to La Palma. The planning has already begun. How many lenses to take; how to divide my time up on top of the mountain; and wondering how many scary monsters are going to try and eat me. The plan is to drive up to as close as I can to the international telescopes and this time, using a tracking mount, capture tracked images of the Milky Way.

Jason Hart
Jupiter and its moons are an obvious target during the short nights of late spring and early summer, but globular clusters are favourites of mine as well, and M13, M3 and M5 are all well-placed during this period.

William Wickham
Mars is coming into opposition in July.

Steve Green
Mostly clouds :(

Tony Horton
I'd love to photograph some noctilucent clouds for the first time, so that'll be top of my list for the coming months.

Simon Whitfield
Summer nights for me usually means the Moon, planets and – if the weather plays ball – solar.

Peter McCormick
The calendar, until it gets dark again.

Peter Louer
In Tenerife, we have dark skies all year round.

Anthony Morgan
I want to get back out with my telescope after a few months of not having the chance.

Vince Ralph
I will probably spend lots of nights setting up to then watch clouds that haven't been forecast roll in. Then I'll dismantle the gear in a huff.

OOPS!
In the June issue's Hotshots, Pete Lawrence's image of the Whirlpool Galaxy, M51, on page 29 was incorrectly labelled as the Pinwheel Galaxy.

In the article about The June Sun on page 52 of the June issue's Sky Guide, the Sun's declination at solstice should be 23.4369°.

BBC

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Sky at Night MAGAZINE

Hotshots

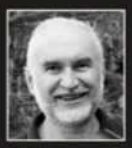
This month's pick of your very best astrophotos

YOUR BONUS CONTENT

A gallery containing these and more of your stunning images

▲ Star trails at La Silla

ZDENĚK BARDON, LA SILLA OBSERVATORY, CHILE, 14 MARCH 2018

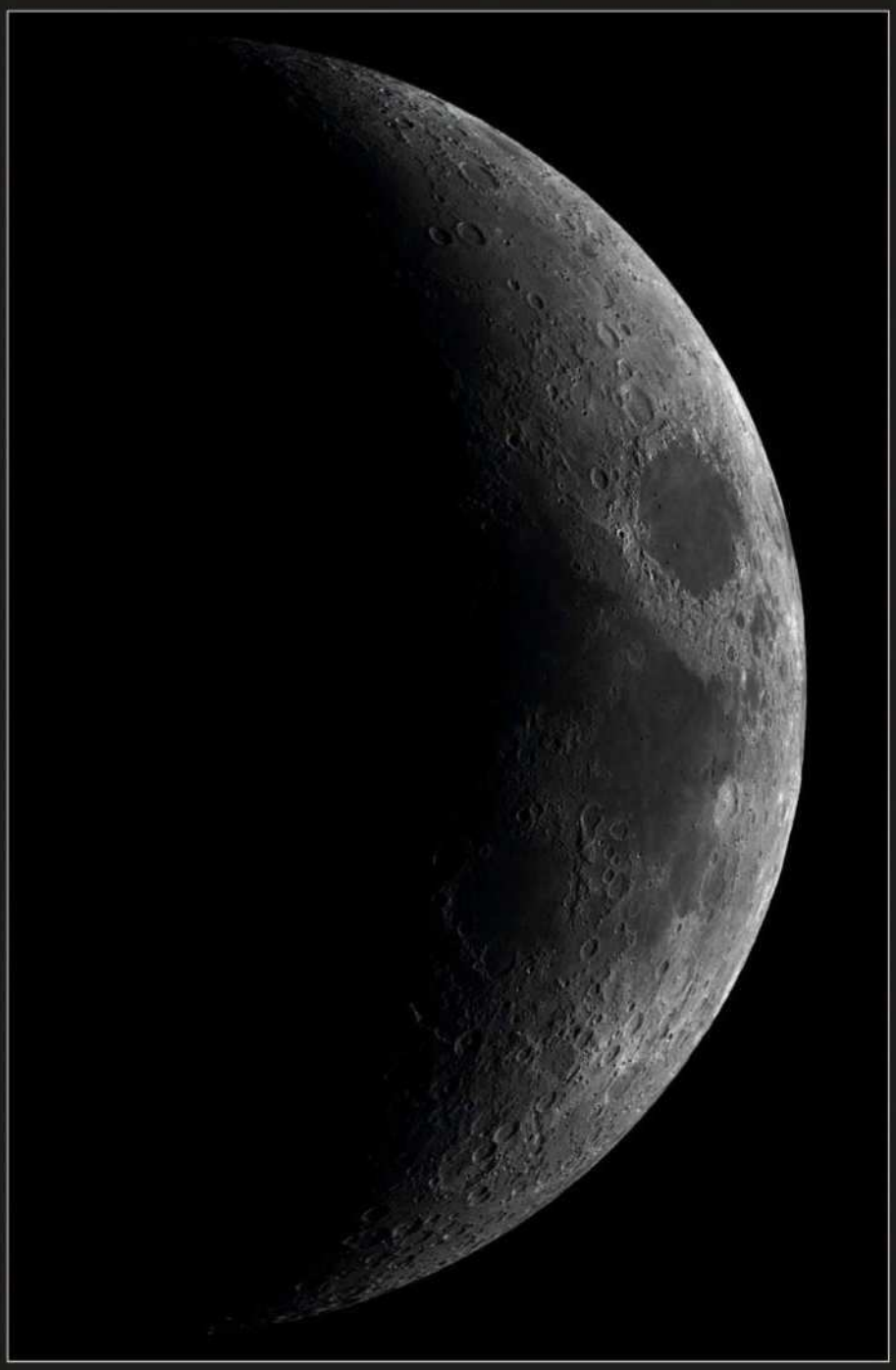


Zdeněk says : "After a 15-hour flight to La Silla, I found myself in the middle of a stark desert. As much as the area may seem inhospitable, it is paradise for astronomers: a place that prides itself on its dark blue hues and crystal-clear sky. Because of the expansive terrain, it is not an easy task to reach the observatory; however, it is a once-in-a-lifetime experience. To see Orion upside down and 'drowning' in thousands of stars was unforgettable."

Equipment: Nikon D810A DSLR camera, Zeiss Milvus 2.8/18 lens, tripod.

***BBC Sky at Night Magazine* says:** "Full marks go to Zdeněk for making the most out of his trip to the Atacama Desert and taking advantage of the dark skies it has to offer. The most impressive aspect of this image is the star trail reflection in the Swedish-ESO Submillimetre Telescope radio dish. A fitting tribute to one of the most important astronomical sites on Earth."

About Zdeněk: "I have been an amateur astronomer for more than 45 years. My first telescopes were made out of cardboard tubes and lenses from glasses, but a number of years ago I built a fully robotic observatory in my garden that can capture images throughout the night. I am an exuberant astronomer and cannot miss a single opportunity to capture an image of the Milky Way. Taking great images is not difficult, but it involves a notable amount of experience, a great deal of patience and good equipment."



▲ Crescent Moon

ANDREW RICHENS, SOUTH LINCOLNSHIRE, 20 APRIL 2018

Andrew says: "The waxing crescent Moon is an excellent time to view the Messier double crater in Mare Fecunditatis with two bright rays running to the west. The double central mountains in the heart of Langrenus are also visible rising up over 1km from the crater floor below. Unfortunately, our neighbour's house prevents clear views to the west so I had to capture all the mosaic frames quickly."

Equipment: ZWO ASI 290MM mono CMOS camera, Sky-Watcher Explorer-200P Newtonian, Sky-Watcher HEQ5 Pro SynScan mount.

▼ Great Globular Cluster

GARY YULE, MANCHESTER, 2 MARCH – 14 APRIL 2018

Gary says: "M13 was nicely placed in the sky above where I live: it's the only horizon I have that means I'm not shooting over houses from my backyard. I put in an hour and the result came out quite well so over the next few weeks – after imaging other targets – I kept turning back to M13 to capture more data. This image is the result of nine hours' total work."

Equipment: Nikon D5100 DSLR camera, Opticstar ARX200 Flat-Field Astrograph 8-inch Newtonian, Sky-Watcher HEQ5 Pro SynScan mount.

▼ The Pelican Nebula

IAN DUNBAR, WEST MIDLANDS, OCTOBER 2017

Ian says: "This is the first time I've imaged the Pelican at this image scale and I'm pleased with the detail. Plus the fact that I managed to capture the evidence of star formation shown within Herbig–Haro Object 555."

Equipment: Atik 460EX CCD camera, Orion Optics VX10 Newtonian, Sky-Watcher AZ EQ6-GT mount.

◀ Craters Theophilus, Cyrillus and Catharina

CHRISTOPHER PLATKIW, DERBYSHIRE, 21 APRIL 2018

Christopher says: "I love the contrast of light and shadow near the terminator and the symmetry of Theophilus and Cyrillus, with the distinctive egg-shaped impact crater in Cyrillus lit up in sunlight."

Equipment: QHY5II-C CCD camera, Sky-Watcher Skymax 150 Pro Maksutov-Cassegrain, Sky-Watcher HEQ5 Pro SynScan.

▼ Antares region

RAFAEL COMPASSI, PRESIDENTE LUCENA, BRAZIL, 23 APRIL 2018

Rafael says: "I had been trying to capture this region for two years and at last I pulled it off. I 3D-printed an adaptor so I could use a DSLR lens with the ZWO ASI1600 mono camera and filter wheel."

Equipment: ZWO ASI 1600MM mono CMOS camera, equatorial mount, Nikkor 135mm lens.

◀ The Sun

DAVID PICKLES, NORTHANTS, 14 APRIL 2018

David says: "To capture detail in both the surface features and the prominences I used different exposure lengths, combining them to produce a single composite image for, I think, a far more interesting result."

Equipment: Altair GPCAM 290 mono camera, Lunt LS50THa B600 h-alpha solar telescope, Celestron Evolution mount.

▼ The Pinwheel Galaxy

JAY BOLT, WEST YORKSHIRE, 17, 18, 20 APRIL 2018

Jay says: "This winter, I had hoped to target several galaxies but the weather has been awful. When a window finally opened at the end of April, I decided on M101 as it was in an ideal position to maximise the time I could spend on it each night."

Equipment: QHY163M CMOS camera, Sky-Watcher Explorer 130P-DS Newtonian, Sky-Watcher EQ6-R Pro mount.

▲ The Iris Nebula

GERARD TÀRTALO MONTARDIT, HUESCA, SPAIN, 14 & 20 APRIL 2018

Gerard says: "The first night I could only integrate 35 minutes of exposure, because of the high humidity that kept fogging the Newtonian's mirrors. I was not satisfied because the brown dust around the nebula was not visible, so I went out the following weekend in search of adding more exposure to the image."

Equipment: Canon EOS 600D DSLR camera, Sky-Watcher Explorer 150/750P-DS Newtonian, Sky-Watcher NEQ6 Pro mount.

The size and frequency of coronal mass ejections varies according to a cycle, which, worryingly, predicts that we're due a huge one very soon

ISTOCK

SUPERFLARES: Earth under threat

The risk to our planet from coronal mass ejections may have been seriously underestimated, as **Marcus Chown** discovers

ABOUT THE WRITER
Marcus Chown is a science journalist and author of *The Sunday Times* science book for 2017, *The Ascent of Gravity*

The energy of the Sun powers all living things on Earth, alongside all the advances in human technological civilisation. But what the Sun has so generously given us it could take away in an instant. According to two astronomers in the US, a 'superflare' could send us back to the pre-electrical age or, at worst, trigger a global mass extinction.

Manasvi Lingam and Abraham Loeb of the Harvard-Smithsonian Center for Astrophysics say much attention has been paid by scientists and governments to the threat of an asteroid impact on Earth but very little to the threat posed by a violent eruption from the Sun. And they believe the latter is at least as serious a threat as the former.

What has brought this threat into sharp focus is the observation of around 100,000 Sun-like stars by NASA's Kepler satellite in Earth orbit. To everyone's surprise, such stars are not as stable as previously thought but instead prone to extraordinarily violent outbursts, and the obvious inference is that the Sun may be no different.

If the Sun were merely a hot ball of gas, it would be dull and boring, its behaviour easy to understand and predict. In fact, in the 1920s, the venerable English astronomer Sir Arthur Eddington was able to devise a theory of what was going on in the solar interior despite having no knowledge of the nuclear reactions that are the Sun's ultimate power source.

The Sun, however, is not merely a hot ball of gas: what changes everything – and makes it capable of launching deadly solar flares into space – is the presence of its magnetic field.

The Sun of all fears

The Sun's magnetic field, which is not unlike that of a bar magnet, is generated by electrically charged currents of matter that are constantly churning deep within its interior. Because the Sun is not a solid body, its interior rotates at a different rate to its surface and its rotation speed also varies with latitude. This causes the solar magnetic field 'lines' to wind up, storing up energy like twisted rubber bands.

When the tension becomes too great, these field lines 'reconnect' to a lower-energy state. High-energy protons and electrons, which were formerly confined by the field, are suddenly ▸

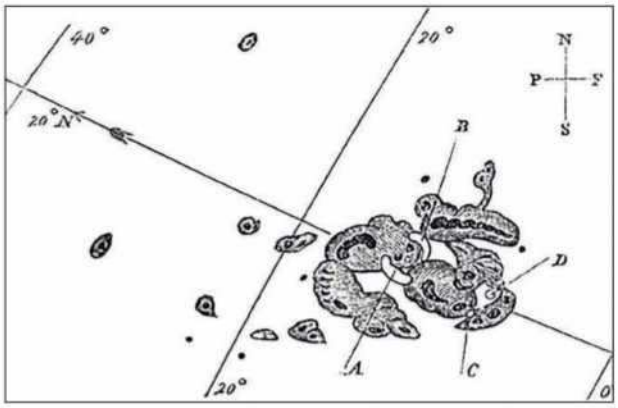
A dramatic visual of a coronal mass ejection (CME) composited from two images captured by the Solar and Heliospheric Observatory (SOHO) – one of the Sun, the other of the CME – taken at roughly the same time in January 2002

▸ set free and violently catapulted off into space. This is what is known a solar flare.

The biggest flare in the age of science was recorded by English amateur astronomer Richard Carrington on 1 September 1859. Now dubbed a 'coronal mass ejection', the 'Carrington event' involved the Sun ejecting solar material comparable to the mass of Mount Everest at about 1,000 times the speed of a passenger jet. When the magnetic field it carried reached the Earth, it sliced through electrical conductors, inducing currents so massive they were enough to electrocute telegraph operators.

What is worrying about Kepler's observations is that they reveal flares on solar, or G-type, stars up to 20,000 times bigger than the Carrington event. Fortunately for us, such enormous flares appear to occur only every 20 million years or so on any given star. However, Lingam and Loeb point out that there is some evidence of a 26 million-year periodicity in terrestrial extinction events. They speculate that, if this is real, it could be explained by superflares.

A flare essentially creates high-velocity protons and high-energy ultraviolet light. Both have the ability to destroy the ozone shield that protects life on the surface of the Earth from deadly solar ultraviolet radiation. Not only can such ultraviolet directly damage the DNA of organisms but it can reduce the ability of phytoplankton to photosynthesise, a process on which life in the oceans depends. As such organisms decline, so too does their ability to suck the greenhouse gas carbon dioxide from the atmosphere, resulting in rising



◂ A sketch of the sunspots seen by Richard Carrington on 1 September 1859. He watched as the points of activity marked A and B moved to points C and D over the course of five minutes, then vanished

"A superflare twice as big as the 1859 one could lead to damage costing as much as the world's gross domestic product"

global temperatures. This was observed during the Carrington event, which warmed the climate of Europe and Russia by up to 7°C. According to Lingam and Loeb, a sharp rise in global temperature from a much bigger stellar flare could be catastrophic for living things, which generally have an optimal body temperature outside of which vital biochemical processes are no longer stable.

But it is not necessarily just the megaflare events that we should be worried about. Kepler's observations reveal that superflares 2,000 times larger than the Carrington event occur roughly every 200,000 years; events 200 times larger every 20,000 years; events 20 times larger every 2,000 years; and events twice the size every 200 years.

A very modern threat

Even another relatively small event on the same scale as the one Carrington observed would be disastrous today. Reportedly, the 1859 event caused a blood-red aurora borealis at low latitudes which was so bright that it was possible to read ▸

OUR MAGNETIC SUN

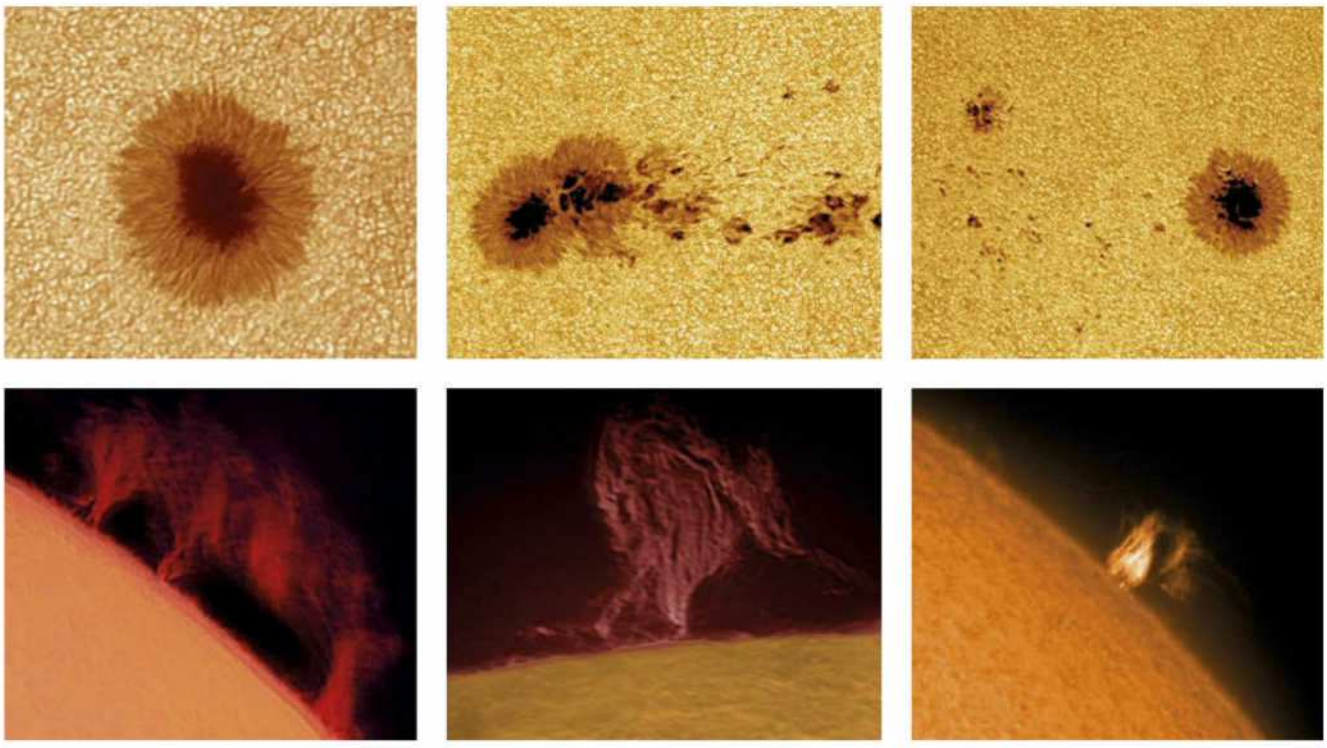
Solar flares and sunspots are generated by the Sun's powerful magnetic field

Often bigger than the Earth, sunspots form when particularly intense magnetic fields break through the Sun's surface. Because the solar material is then held at bay by the magnetic field, the gas inside the Sun does not have to push outwards as hard, and so the area of the sunspot remains cooler and darker than its surroundings.

The number of sunspots grows and declines every 11 years. This solar cycle is related to changes in the Sun's overall magnetic field, which reverses every 11 years. The magnetic north pole becomes the magnetic south pole, and vice versa.

In addition to sunspots, the Sun produces solar flares when its magnetic field lines become twisted like rubber bands until they reach breaking point and catapult matter into space. The biggest events, when huge quantities of matter and electromagnetic radiation are ejected, are known as coronal mass ejections (CME).

The Sun's magnetic field is thought to be created by electrically charged currents of gas circulating in its interior. By rights, such a dynamo should run down, as it loses energy to its surroundings. However, a combination of solar rotation and hot matter convecting from below appears to keep the magnetic dynamo going.

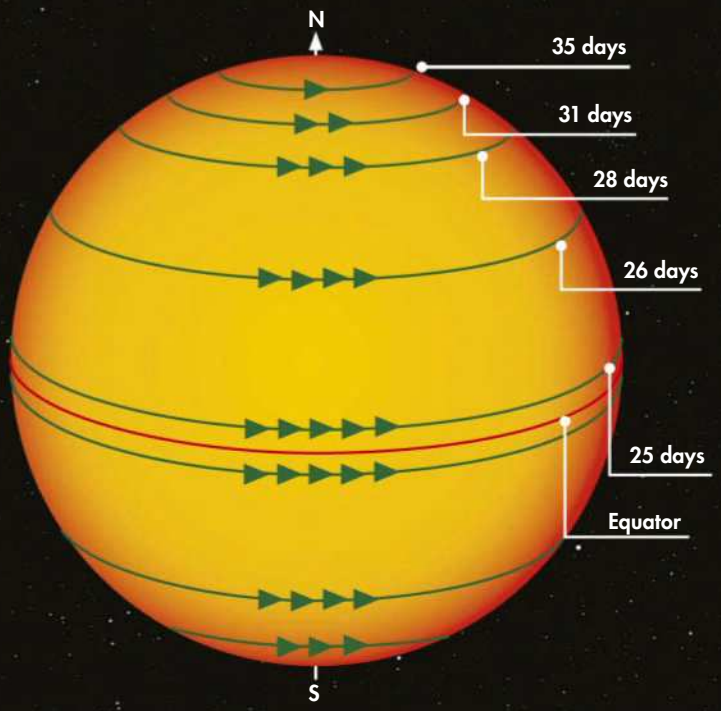


▲ **A selection of amateur astrophographers' images of sunspots (top row) and solar prominences (bottom row). Prominences maintain their loop form and remain anchored to the Sun while flares are eruptions that break free from the Sun and fling protons and electrons into space**

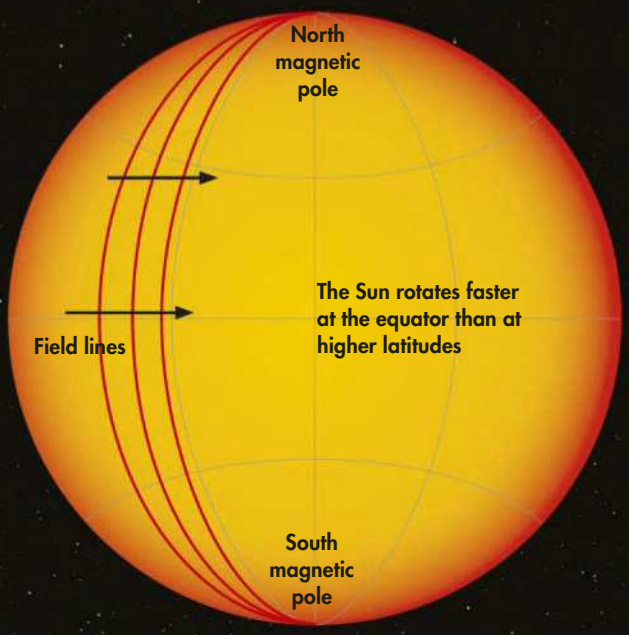
SOHO (ESA & NASA), OLIVER SCHNEIDER/CCDGUIDE.COM X 3, MICHAEL KARRER/CCDGUIDE.COM X 2, CHRISTIAN FRIEBER/CCDGUIDE.COM

HOW SUNSPOTS AND FLARES DEVELOP

Because the Sun is a seething sphere of superhot gas it rotates at different speeds, causing sunspots to form



By observing the motion of sunspots, astronomers have worked out that the Sun rotates on its axis once in about 27 days. But its equatorial regions rotate faster than its polar regions (see above).



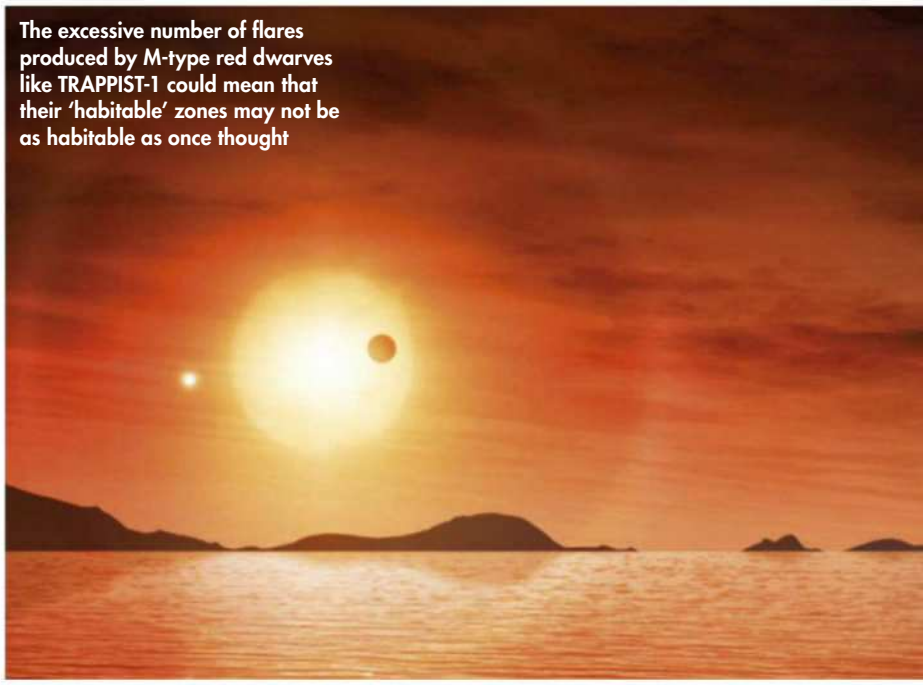
After a period of relative calm during each 11-year solar cycle, the differential in the rate of the Sun's rotation between its equator and its poles starts to warp the Sun's magnetic field.

▸ a newspaper at midnight by its light. However, in 1859, global civilisation was not particularly vulnerable to such flares because there was very little technological infrastructure for it to affect. Today, by contrast, we live in an electrically connected world. A Carrington-scale event would induce massive electrical currents that would melt our power stations, our transformers and our electrical transmission grid, while also potentially destroying critical Earth-orbiting satellites used for communications, weather forecasting and surveillance. In fact, a solar flare caused a major power outage in Quebec on 13 March 1989.

It could cost us the world

A Carrington-like event today would cost the US alone around $2 trillion (around £1.5 trillion). The loss of about 10 per cent of all satellites would set the world back around £70 billion. And it is estimated that a superflare only twice as big as the 1859 one would lead to damage costing as much as the world's Gross Domestic Product.

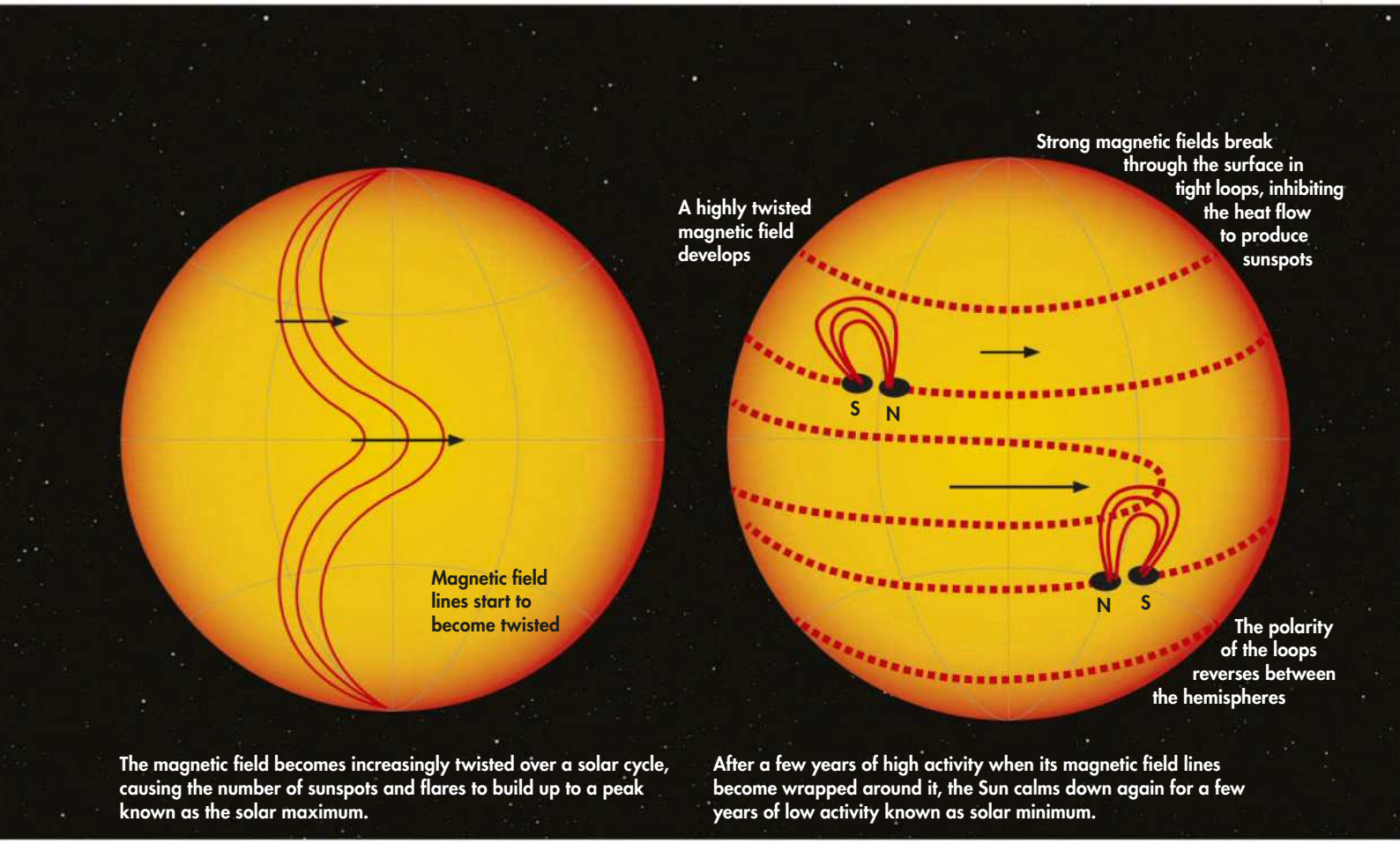
According to Lingam and Loeb, we can expect another Carrington-like within the next 100 years. In fact, there is tentative evidence – from radioactive nuclei in tree rings – that the Earth was subject to an event even bigger than the Carrington one in 775 AD and possibly also in 993 AD. Lingam and Loeb believe superflares should be taken more seriously as severe threats to human civilisation. "Humanity might witness a superflare event in the next century leading to devastating economic and technological losses," believes Loeb.



The excessive number of flares produced by M-type red dwarves like TRAPPIST-1 could mean that their 'habitable' zones may not be as habitable as once thought

But, if superflares on Sun-type stars are more frequent than anyone expected, they pale into insignificance when compared with superflares on cooler, M-type and K-type dwarf stars, which are not only bigger but also more frequent. This

PAUL WOOTTON X 4, MARK GARLICK



The magnetic field becomes increasingly twisted over a solar cycle, causing the number of sunspots and flares to build up to a peak known as the solar maximum.

After a few years of high activity when its magnetic field lines become wrapped around it, the Sun calms down again for a few years of low activity known as solar minimum.

has implications for the prospects of finding life elsewhere in our Galaxy. M-type red dwarves account for about 70 per cent of all the stars in the Milky Way, so the discovery of planets in orbit around such stars has lead some astronomers to claim they may be the most likely places to find extraterrestrial life. The red dwarf TRAPPIST-1, for instance, is accompanied by a family of at least seven planets, three of which orbit within the star's 'habitable zone', the region of space where it is cool enough for water not to boil and hot enough for it not to freeze.

Vulnerable exoplanets

Lingam and Loeb point out that, because red dwarves are so cool, the habitable zones of such stars are necessarily very close in, making them extremely vulnerable to flares. This would be a serious problem even if such stars had outbursts as big as the Sun. However, their flares are much more violent. Not only do they have the potential to erase any life on the surface of orbiting planets but the energy they deposit on a planetary surface may be sufficient to boil off any oceans, provided they are comparable in size to Earth's. This is all bad news for astronomers hoping to find life on Alpha Centauri Bb, the planet orbiting one of the stars in the nearest star system to Earth.

K-type stars are not as prone to violent outbursts as M-type ones but they are still more dangerous than solar-type stars. Ironically, dwarf stars with a tenth of the mass of the Sun could live 1,000 times longer than our star and are much more abundant than similar stars which, if not for the flares, would make them ideal candidates for the development of life. "The outbursts may help explain why we, homo sapiens, find ourselves living on a planet orbiting the Sun today and not in the habitable zone of an M-dwarf that would outlive the Sun for 10 trillion years," says Loeb.

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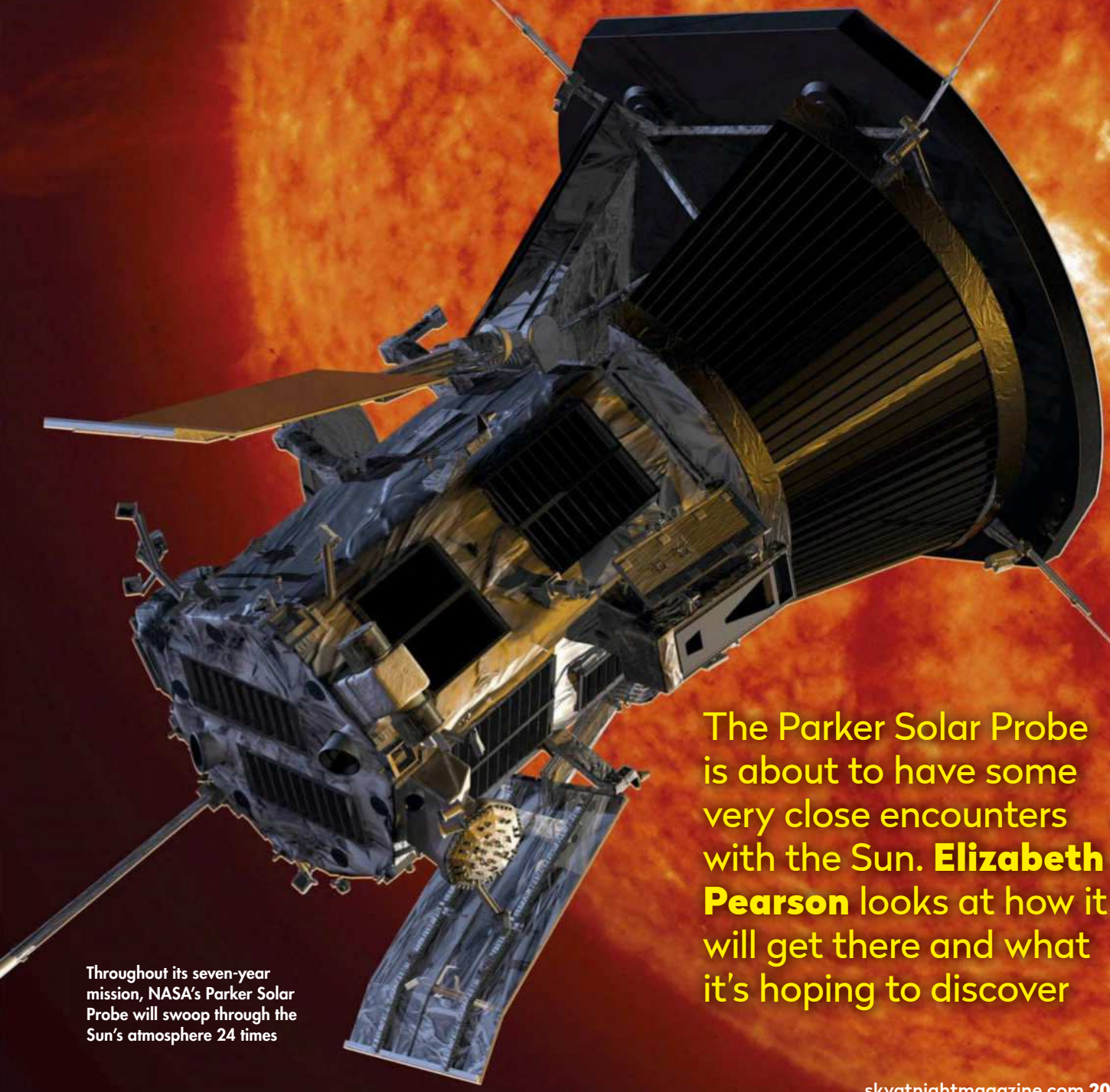
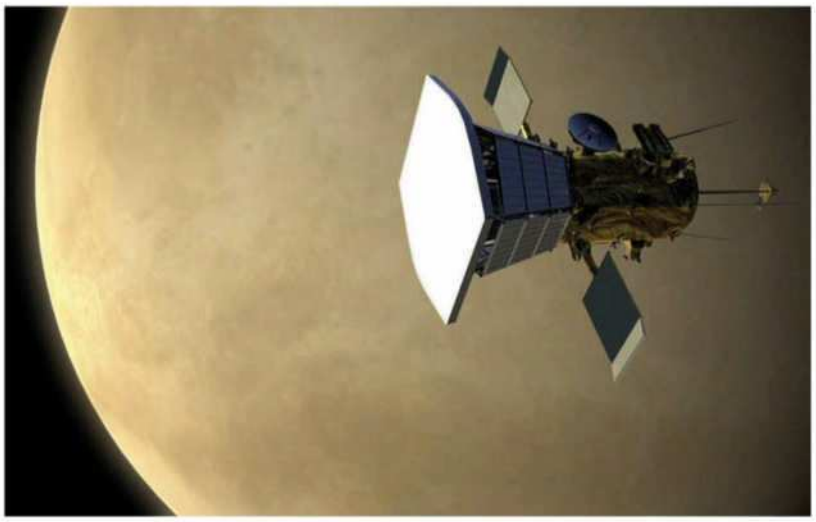
JOURNEY to the centre of the SOLAR SYSTEM



Throughout its seven-year mission, NASA's Parker Solar Probe will swoop through the Sun's atmosphere 24 times

The Parker Solar Probe is about to have some very close encounters with the Sun. **Elizabeth Pearson** looks at how it will get there and what it's hoping to discover

NASA/JOHNS HOPKINS APL/STEVE GRIBBEN



▲ The Parker Solar Probe is the first NASA mission to be named after a living person, astrophysicist Eugene Parker

The Sun is the pulsating heart of our Solar System. Its gravity controls the motions of the planets; its heat and light define their climates; and its energy makes all life on Earth possible. Without the Sun, the Solar System simply would not exist.

And yet we know surprisingly little about our own star. Few of the hundreds of space missions flown in the last 60 years have been sent towards the Sun and the handful that have made the journey inwards have looked on from a distance, far away from the worst of the Sun's ferocity.

Not so with NASA's Parker Solar Probe, which launches at the end of July. The mission will make a dive towards the Sun, travelling right through the corona, passing a mere 6.3 million km from our star's surface (4.5 times the diameter of the Sun), the closest any spacecraft has ever come to the Sun.

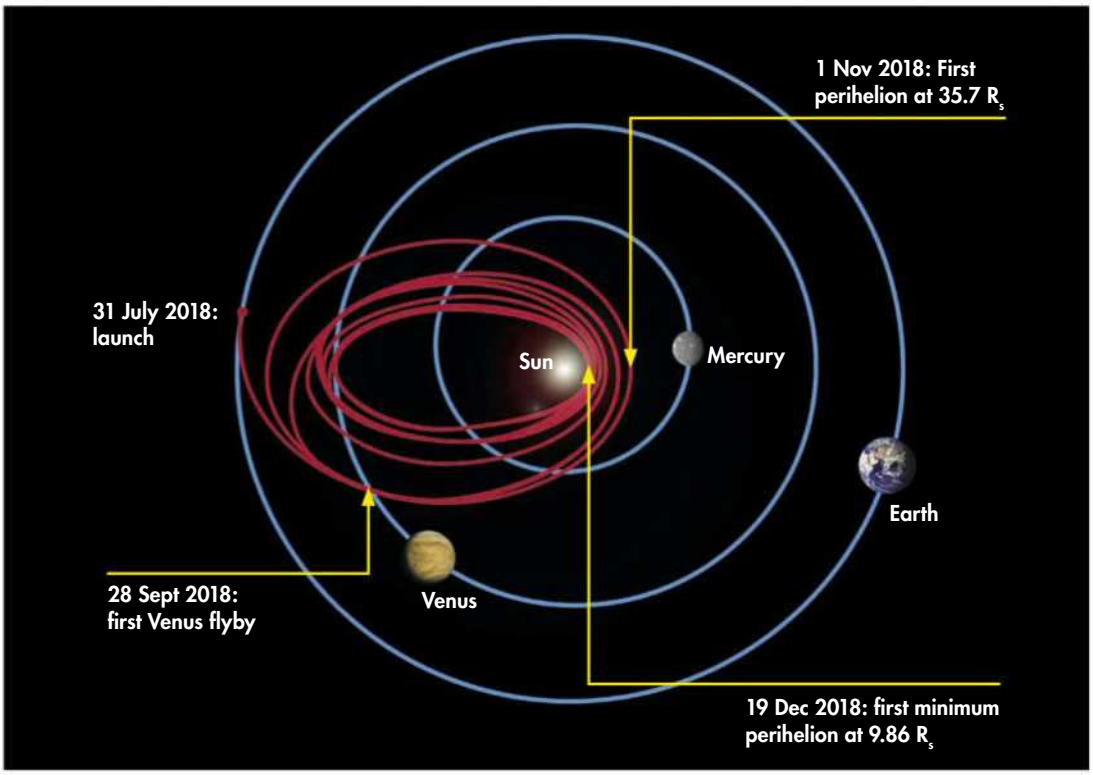
"For the first time we are really going to sample the coronal material," says Nicola Fox, the project scientist for the Parker Solar Probe mission. "It's a real voyage of discovery."

With a little help from Venus

Getting there, however, will be no easy feat. Parker will hurtle towards the Sun at a speed of 690,000km/h, becoming the fastest man-made object ever built, shattering the previous record of 145,000km/h set by Juno. But even that won't be enough to get the probe into orbit around the Sun, so the mission will have to get a push (or seven) along the way.

"The Parker Solar Probe mission will use Venus to do gravity assists," explains Fox. "Each pass will be a bit like a handbrake turn in a car, letting us focus the orbit a little bit closer to the Sun

"Parker will hurtle towards the Sun at 690,000km/h becoming the fastest man-made object ever built"



JHU/APL X 2, NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY, NASA/JOHNS HOPKINS APL/ED WHITMAN

◄ A graphical representation of the mission showing the seven Venus flybys. R_s stands for Solar Radius. For comparison, Earth is just a smidgen under 215 R_s from the Sun

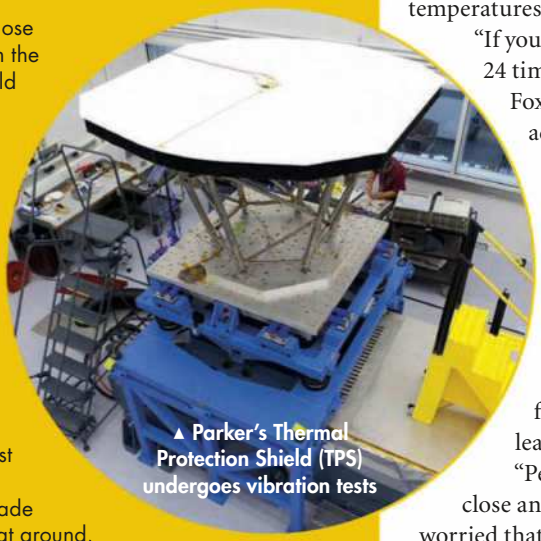
ABOUT THE WRITER
Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in galactic astronomy at Cardiff University

Surviving the INFERNO

Parker will pass closer to the Sun than any human-made object before it, but how will it stay safe?

To survive temperatures up to 1,400°C at close quarters to the Sun, Parker is equipped with the Thermal Protection System (TPS): a sun shield 12cm thick and over 2m in diameter.

"The TPS is made of super-thin sheets of a carbon material a bit like what's used in graphite golf clubs and tennis rackets," says Fox. "Then there's foam in-between. This is covered in a white alumina, like a ceramic. That reflects a lot of the Sun's light and the rest is absorbed and used to keep the rest of the spacecraft warm. It sounds ironic, but we're almost more concerned about things getting cold rather than getting hot."



▲ Parker's Thermal Protection Shield (TPS) undergoes vibration tests

Behind the shield Parker needs to be heated because the instruments operate best at room temperature. Though it might be scorching in the sunshine, it's cool in the shade and without an atmosphere to move the heat around, temperatures drop dramatically. Maintaining this delicate balance requires Parker to stay precisely aligned so that its instruments are always in shadow. With an eight-minute delay between Earth and the Sun there's no way that Parker could be controlled from the ground.

"She has to look after herself," says Fox. "If a sensor's in the sunlight when it shouldn't be, Parker has to figure out what thruster it needs to fire to turn. The sheer amount of technology that had to be developed is why Parker has taken 60 years in development. It's not a forgiving environment we're going to."

Parker is rolled into the Acoustic Test Chamber at NASA's Goddard Space Flight Centre in Maryland

each time. The first one will be six weeks after the launch, with another six flybys over seven years."

The initial mission will pass through perihelion, its closest approach to the Sun, 24 times. During these times, it will have to endure temperatures up to 1,400°C. In-between, the spacecraft will swing back out to the orbit of Venus where the temperatures will drop to below freezing.

"If you take any material and heat it and cool it 24 times it will become brittle or elastic," says Fox. "Coming up with materials that can actually withstand these big temperature swings was a big development."

The temperature isn't the only thing that will be extreme about this environment. The probe could end up in the middle of one of the Sun's most energetic events: a solar flare or a coronal mass ejection. But while most space probes have to shy away from these explosions, Parker will be leaning into them.

"People ask if I'm worried we'll be up close and hit by a solar flare, but I'm actually worried that we'll get really close and we *won't* get hit by one," says Fox. "We want to see coronal mass ejections. We want to see all kinds of solar activity from the quieter than quiet to the very active."

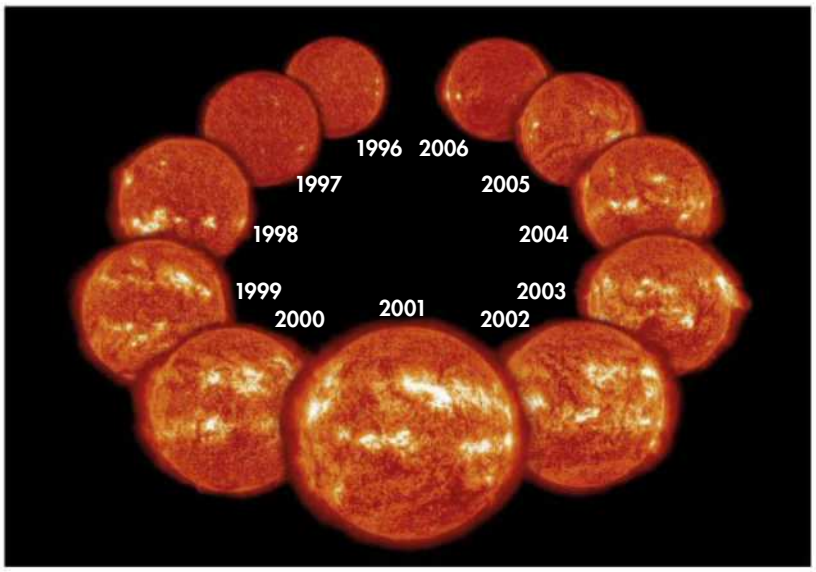
Parker's particle detector experiments – Integrated Science Investigation of the Sun (ISIS) and Solar Wind Electrons Alphas and Protons (SWEAP) – will be able to measure the type, energy, speed and temperature of the particles as they are thrown out by a flare. Researchers back on Earth will then be able to compare these results to what the instruments saw when there were no flares, giving a unique insight into these solar events.

Strange cooling is a hot topic

The probe will get its first opportunity to catch a flare in the act of erupting when it makes its first trip through perihelion around three months after launch. From this close-up viewpoint, Parker will start gathering data that will help answer some of the questions we still have about the Sun.

"One of the big mysteries is that the temperature in the corona is around 300 times hotter than the surface of the Sun. That makes no sense: when you walk away from a campfire you get colder not hotter, so what's going on?" says Fox.

One of the most popular theories about what's causing this was put forward in the 1970s by Eugene Parker, the solar scientist after whom the mission is named. What we know for a fact is that where the temperature is at its height, the particles in the corona are also being energised until they have enough speed to pull away from the Sun's surface and accelerate into interplanetary space. As they pull away, a portion of the solar magnetic field ▸



▲ Over the 11-year solar cycle the Sun swings from periods of minimal activity to peak activity

NASA, NASA/JOHNS HOPKINS APL/STEVE GRIBBEN X 2, ISTOCK

▸ itself becomes trapped by the gas and carried away with it. Parker's suggestion was that nanoflares – tiny solar flares too small to be seen from Earth – convert the energy in the trapped magnetic field to heat. But this is just one theory.

"No single theory can explain everything that goes on around the Sun," says Fox. "There are many competing ideas and Parker's is the one a lot of people think could be true. We're certainly going to see if we can find these nanoflares."

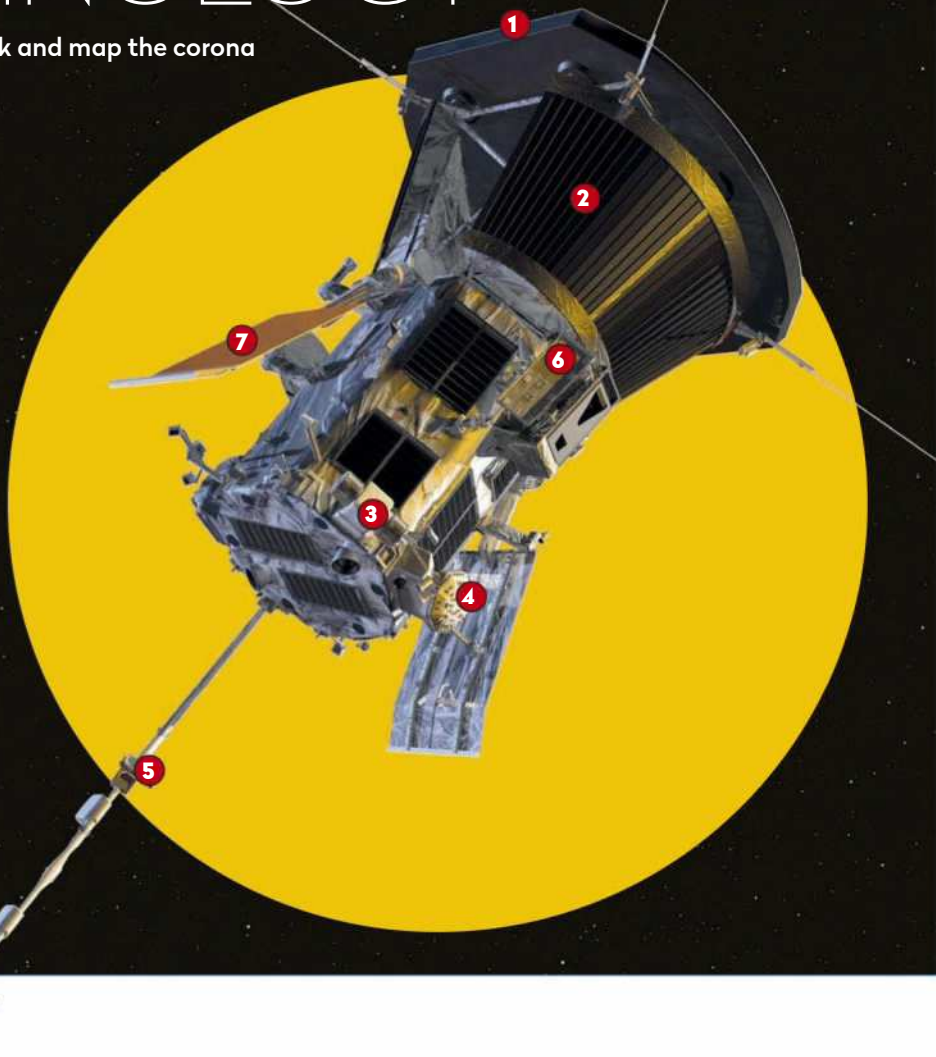
Solar magnetic field experiment

The Parker Solar Probe will attempt to uncover these nanoflares by listening out for their radio signals using the FIELDS Experiment. The instrument will also map out one of the largest structures in the Solar System: the solar magnetic field, which extends 14.5 billion km from the Sun, or twice the distance to Pluto. The field has a profound effect on the planets and their atmospheres, but we still know little about how it is created.

One of the biggest questions that astronomers hope to answer using FIELDS is the reason for

HOT TECHNOLOGY

The spacecraft's suite of instruments will track and map the corona



1. Thermal Protection System (TPS) – The heat shield is 12cm thick, and 2.3m in diameter. Its white surface reflects most of the Sun's heat to keep the instruments at a comfortable room temperature.

2. Solar Array Radiators – Four racks of thin tubes are filled with warm water to help radiate away the excess heat absorbed by the heat shield.

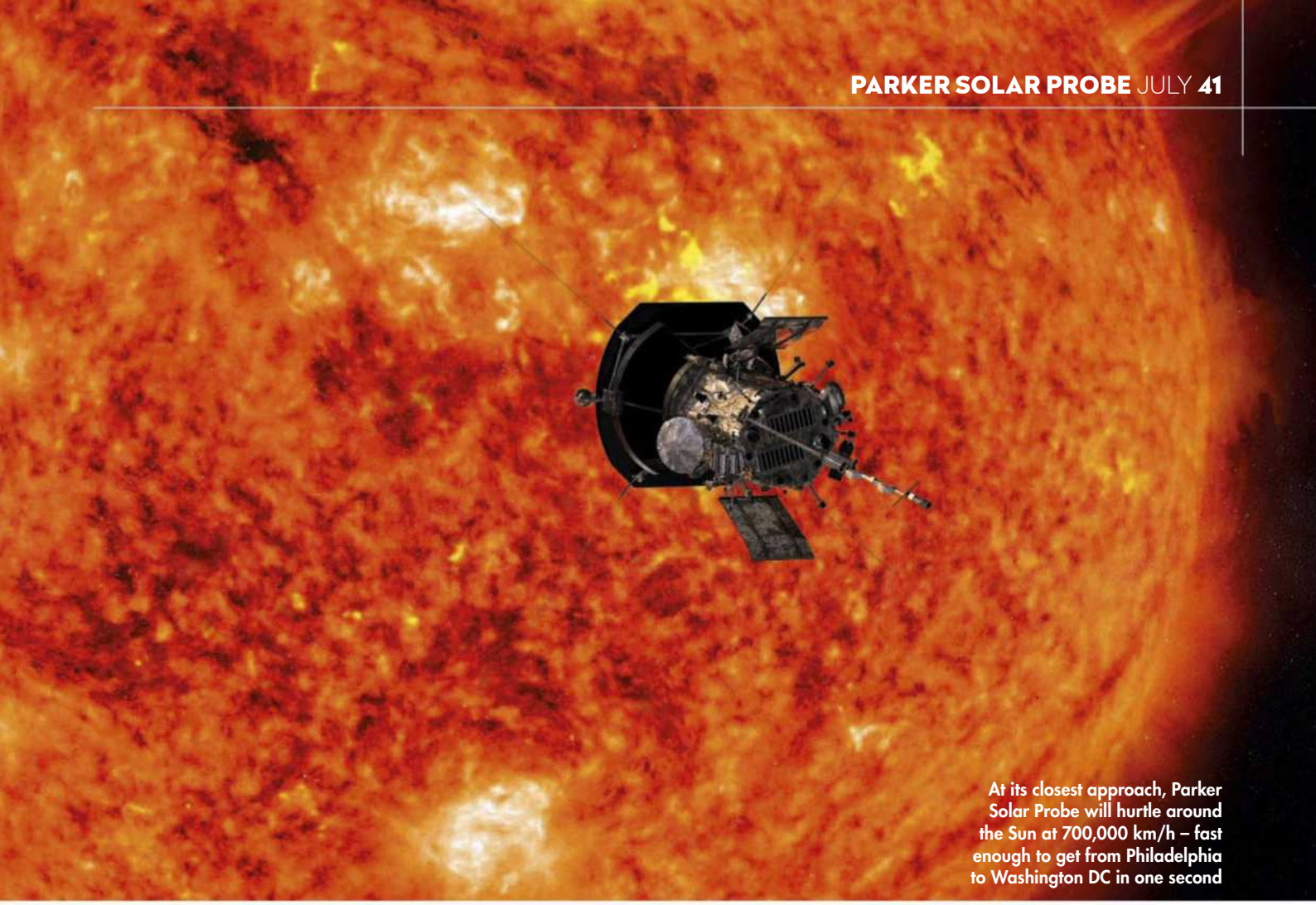
3. Solar Wind Electrons Alphas and Protons Investigation (SWEAP) – Takes samples of the coronal material and then analyses main components – electrons, protons and helium atoms.

4. Integrated Science Investigation of the Sun (ISIS) – Observes charged particles in the Sun's atmosphere that are highly energised, and so could pose a risk to future astronauts.

5. FIELDS Experiment – Takes direct measurements of the Sun's magnetic and electric fields, as well as measuring plasma density, electron temperature and radio emissions.

6. Wide-field Imager for Solar Probe (WISPR) – The camera will take 3D images of the solar wind as it approaches and passes the spacecraft to provide context for the other instruments.

7. Solar Array – During the closest approach the solar arrays that power the craft will get 25 times more energy than they would while orbiting Earth.



At its closest approach, Parker Solar Probe will hurtle around the Sun at 700,000 km/h – fast enough to get from Philadelphia to Washington DC in one second

What is the CORONA?

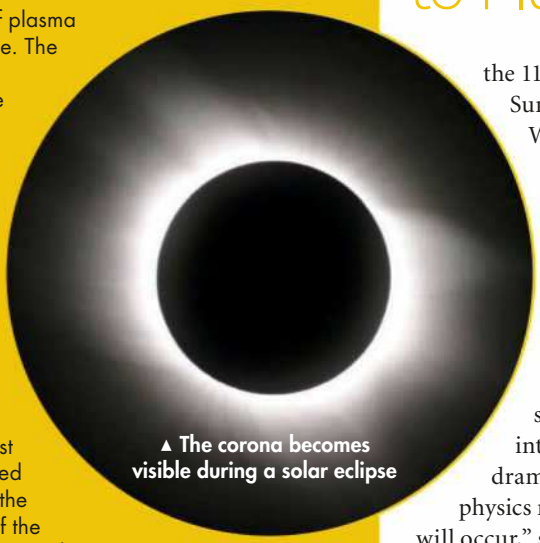
The solar atmosphere extends many times further than the optical face of the Sun

The Sun is surrounded by an atmosphere of plasma that extends millions of kilometres into space. The outermost part is called the corona.

But rather than being a uniform cloud the plasma follows the Sun's magnetic field lines, creating loops that double back towards the surface or huge petals which reach far out into space.

During the most active times of the solar cycle, the material is fairly evenly distributed, but this is not always the case. At quieter times, the coronal plasma tends to gather around the equator, leaving gaps at the poles known as coronal holes.

Along with the plasma, dust gets caught up in these structures. Usually, the dust is lost in the Sun's glare, but when the Sun is blotted out, such as during an eclipse, we can see the corona because of the sunlight reflecting off the dust. It will be possible for Parker's only camera, the Wide-field Imager for Solar Probe (WISPR), to observe the structures of the solar wind by imaging the dust that flows along with it. This will help to give context to the other observations.



▲ The corona becomes visible during a solar eclipse

"Parker will map out the solar magnetic field, which extends twice the distance to Pluto"

the 11-year solar cycle, which causes the Sun's magnetic poles to exchange places. When the Sun is mid-flip, the number of sunspots, flares and coronal mass ejections dramatically increases. And when these reach Earth, they interact with our own magnetic field to create what can be quite extreme outbursts of space weather.

"That interaction produces the aurora, but it can also cripple satellites, affect power grids and interfere with GPS systems. Parker will dramatically improve our knowledge of the physics needed to predict when these events will occur," says Fox.

The path to creating the Parker Solar Probe has been a long one, but the mission is now finally ready to begin its journey and reveal the mysteries that lie at the centre of our Solar System.

ABOUT THE WRITER
Science writer and editor Shaoni Bhattacharya has loved rockets since watching Space Shuttle launches as a child

Dependent on some rigorous testing, both SpaceX's Crew Dragon, (top) and Boeing's Starliner (below) will be ferrying NASA astronauts to the ISS

The American rocket DREAM

With test flights as early as August **Shaoni Bhattacharya** looks at NASA's plans to turn manned space flight over to the private sector

When Space Shuttle Columbia exploded seconds after re-entering Earth's atmosphere in 2003, killing all seven crew members, the tragedy set in motion a sea-change in human spaceflight. NASA's Space Shuttle programme was eventually cancelled in 2011, leaving it reliant on Russian Soyuz rockets and capsules to get astronauts to and from the International Space Station (ISS). Now NASA looks like it will finally be getting back to ferrying its own astronauts to low Earth orbit, just as human spaceflight is entering a new commercial era.

If all goes to plan, by next year it won't be just governments and official agencies putting people into orbit in the International Space Station, but companies too; namely Boeing and Elon Musk's SpaceX. Although NASA has always used private contractors like Boeing to help build its rockets – from Apollo to the Space Shuttle era – the agency has always overseen the development process and operated the final product.

However, says space policy expert Professor Roger Handberg from the University of Central Florida, NASA was never built to be an operational organisation; rather it is tasked with developing technology and exploration. By getting other companies to develop and operate rockets, NASA should free up resources to pursue other goals, such as sending people to the Moon or Mars, for which it is developing its own Orion spacecraft and powerful rocket, the Space Launch System (SLS).

After the Shuttle programme's demise, NASA opened up a commercial competition for the development of its replacement. By 2014, the competitors had been whittled down to Boeing and SpaceX. NASA awarded contracts of $4.2 and $2.6 billion respectively. Once their craft gain NASA certification, the companies are contracted to carry out six missions each to the ISS until 2024, when the Space Station is likely to be decommissioned.

Boeing has steamed ahead with developing its CST-100 Starliner crew capsule, and SpaceX its Crew Dragon, both of which are compatible with multiple launch vehicles such as NASA's Atlas V and SpaceX's own Falcon 9. Both capsules are also reusable, as is the Falcon 9 launcher – a boon in an industry in which multi-billion dollar rockets are usually one-time use only. Both have seats for up to seven passengers.

Reducing a reliance on Russia

First test flights are scheduled for this year but a number of challenges remain: some technical, others more political, such as the use of Russian rocket parts. NASA's ultimate aim is to stop relying on Russia to get American astronauts to the ISS. Even so, NASA has pre-booked seats on Soyuz flights to the ISS in 2019 just in case.

In spite of good collaboration with Russia since the famous 1975 Apollo-Soyuz docking mission, the current space relationship between America and Russia "can get pretty tricky," says Handberg.

"A lot of Americans were very uncomfortable with our dependency on the Russians," he says. "One of the things that the US and NASA always maintain is that, 'We don't allow others to be in the critical position.'" And having American astronauts on the Space Station is a critical part of the programme.

There are various milestones that the two companies have to pass before they can gain ▸

BOEING CORP, SPACEX, ISTOCK X 2

THE REAL SPACE HOTEL

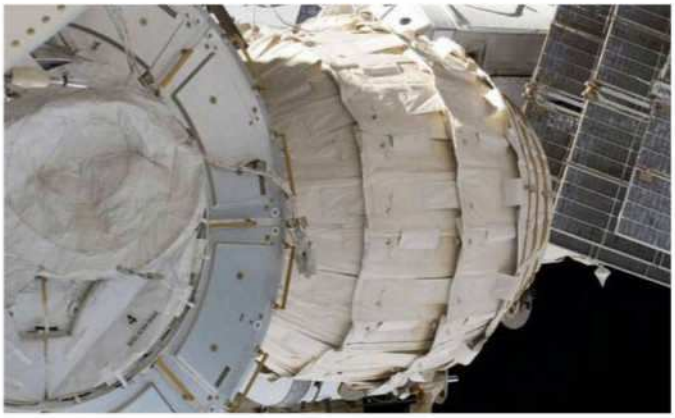
Private rockets – or 'space taxis' – could make astro holidays a reality

Last year SpaceX announced that a pair of tourists have paid deposits to circumnavigate the Moon on Crew Dragon once it's completed its initial NASA duties. Meanwhile Boeing is making one Starliner seat on each trip available to paying members of the public, bookable through the private space flight company Space Adventures.

The Russian Space Agency has taken paying guests to the ISS aboard its Soyuz rockets in the past, but ever since the US Space Shuttle programme was suspended in 2011, any seats going spare have been occupied by American astronauts.

The advent of NASA's Commercial Crew Program (CCP) and other private space ventures hold promise. The ISS already has the privately funded BEAM attached (see below) as a test to see how it stands up to the space environment. Is this the first step towards space hotels? Space policy expert Professor Roger Handberg warns that many obstacles remain. "We are in an interesting stage. We have the potential to get you into orbit but it's still super-expensive; that's why space tourism doesn't make sense."

Besides money, physical ability and endurance may be limiting factors in space tourism. Not everyone will be able or will want to float around for days in a small container. "This isn't like getting on a plane with 600 people and flying out to an island in South Asia," says Handberg. "For the first time we're at a stage where the dreams might work but the reality and the financial aspects are still very, very difficult."



▲ **The Bigelow Expandable Activity Module (BEAM) was berthed to the ISS in 2016, then expanded and pressurised, and will stay there until 2020**

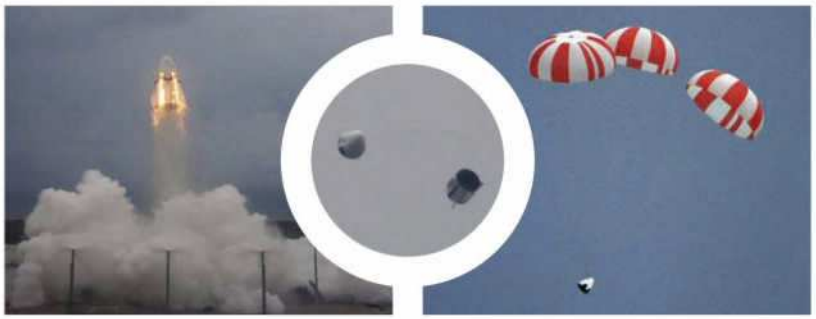
▸ NASA certification. First, both must prove that their rockets can actually fly. The two contenders are scheduled for uncrewed flight tests in August 2018, when their rockets will fly to and from the ISS. They also have to meet safety requirements, including effective abort systems, parachutes, engines and spacesuits, and they must have rehearsed and validated rescue scenarios.

The Crew Dragon successfully passed its 'pad abort test' in May 2015. Unlike previous abort systems – where a rocket tower adjacent to the crew capsule ignites to detach it from the launcher rocket in the event of a failure – the Crew Dragon has an integral abort system: eight SuperDraco rockets built into the wall of the capsule. This means the capsule has the ability to abort at any point, not just at the launch pad.

Mid-flight abort test

After its uncrewed test flight this August, Crew Dragon is also scheduled for an 'inflight abort test' when the Dragon's onboard computers will trigger an 'abort' of the capsule from its Falcon 9 launcher during ascent.

Meanwhile Boeing has been working on fixing an issue with control of the craft in its abort system. "In some abort scenarios, Boeing has found that the spacecraft may tumble and that could pose a threat to the crew's safety," said a January 2018 report by the US Government Accountability Office. To validate its system, the company has been conducting wind tunnel tests and a launch pad test is expected some time around the publication of this issue.



▲ **Crew Dragon passed its pad abort test in 2015. An in-flight abort test is set for August**

The companies have also developed bespoke landing systems. Boeing's Starliner is the first US-built capsule designed to return to land, rather than sea, so it has parachutes and airbags to absorb the shock of a ground-landing. Boeing says this makes the capsule reusable up to 10 times. SpaceX's Crew Dragon will land more conventionally, using parachutes to splash down in water.

Both companies have also been working closely with NASA and the US Department of Defense to test and practise crew recovery scenarios. For Starliner this has meant testing emergency water

SPACEX x 5, ISTOCK, NASA X 2, BOEING, BOEING PHOTO ILLUSTRATION

▲ The sleek, hi-tech interiors of SpaceX's Crew Dragon (left) and Boeing's Starliner (right) are cunningly colour coordinated with their space suits

▲ The capsule for Boeing's Starliner has been designed so that it can land on hard terrain rather than splashing down in the sea

landings, as it is designed to land on ground. Crew Dragon is scheduled for an additional round of these 'rescue trainer tests' off the coast of Florida later this year.

Other tests include validating the engines: Starliner's four launch abort engines and 48 thrusters, and Dragon's Merlin and SuperDraco engines for the Falcon 9.

Boeing has also been conducting parachute tests over Yuma, Arizona, dropping replica capsules from a balloon at 30,000 feet. SpaceX has been dropping its parachute test vehicle from aircraft 25,000 feet over California's Mojave Desert.

A further issue is that the Atlas V launcher has a Russian engine (the RD-180), so Boeing may choose to replace it with a US one: perhaps the New Glenn engine being developed at Jeff Bezos's Blue Origin.

Suited and designer booted

Then there's the spacewear. SpaceX's sleek black and white suit gained much social media attention when Musk revealed it on Instagram last September, with many likening it to *Star Wars*' Stormtrooper armour. Boeing's suit is a distinctive shade of 'Boeing Blue', designed by former astronaut Chris Ferguson and spacesuit company David Clark Co, with space boots designed by David Clark and Reebok. The suit features touchscreen sensitive lightweight gloves, so that astronauts can keep swiping even in space.

To finally gain NASA certification for their rockets, both companies will have to pass an actual flight test with real, live astronauts aboard. Boeing's Starliner is scheduled to undergo its demonstration in November from Cape Canaveral Air Force Station, while SpaceX's Dragon Crew is slated for its test in December from Kennedy Space Center: both flights will carry a pair of NASA astronauts to and from the ISS.

If they pass this ultimate test, then 2019 will herald a momentous new epoch in space travel: American astronauts once again lifting off from US turf, but for the first time hitching rides with private carriers to space.

SpaceX and Boeing's new space suits are a long way from the classic Michelin Man look



The International Astronomy Show 2018

Friday 12 – Saturday 13 October
Stoneleigh Park, Warwickshire
www.ukastroshow.com

The International Astronomy Show returns this October with vendors from across Europe and the USA under one roof, and two days of lectures from world-class speakers, including Prof Chris J Owen and Dr Allan Chapman. The lecture programme covers topics from the solar wind and its interactions with the Earth's atmosphere to mining the Moon and asteroids, and much more. With free parking at the accessible central Midlands venue, and food and drink served all day in the 250-seat restaurant, there'll be something for everyone at IAS 2018!

2-day lecture programme online now! Visit www.ukastroshow.com

All-day admission to exhibition area only £8. Under-16s go free!

EXCLUSIVE MONEY-OFF TICKET OFFER
Get £2 off the price of entrance tickets!

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Terms and conditions

The Promoter is UK Astro Show Ltd, 90 Brandon Rd, Binley, Coventry, CV3. By entering the offer, the participants agree to be bound by these terms and conditions. The offer is for one discount per person of £2 off the full price of entrance tickets worth £8. The offer is redeemable from www.ukastroshow.com/ticket-sales. The offer runs from 16 June 2018 to 27 July 2018. The offer is limited to 1,000 offers. The Promoter will use entrants' personal details in accordance with the Immediate Privacy Policy (www.immediatemedia.co.uk/privacy-policy). There is no cash alternative and the prize will not be transferable. The Promoter reserves the right to amend these terms and conditions or to cancel, alter or amend the promotion at any stage, if deemed necessary in its opinion, or if circumstances arise outside its control. The Promoter excludes liability to the full extent permitted by law for any loss, damage or injury occurring to the participant arising from his or her entry into the promotion. The promotion is subject to the laws of England.

PETE LAWRENCE

The Sky Guide July

When the full Moon rises on 27 July it will be entirely shrouded in Earth's shadow, giving the UK its first total lunar eclipse since September 2015

ABOUT THE WRITERS

Pete Lawrence is an astronomer and astro imager who presents *The Sky at Night* monthly on BBC Four

Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 60

RED LIGHT FRIENDLY

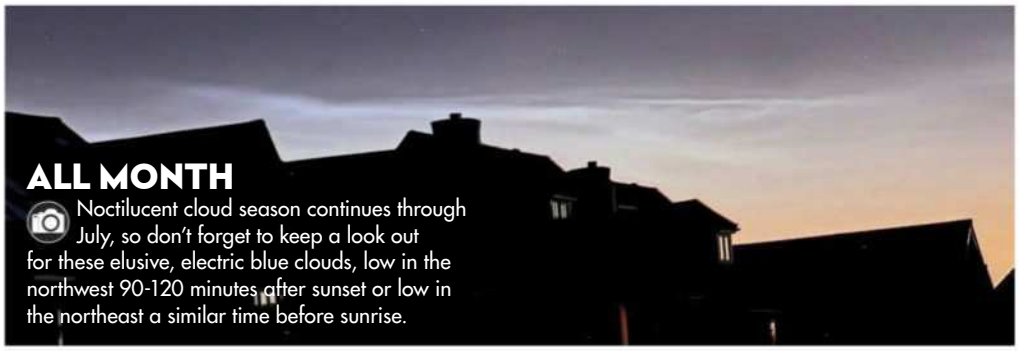
To preserve your night vision, this Sky Guide can be read using a red light under dark skies

DON'T MISS...

- ✦ Mars at opposition will be at its most radiant since 2003
- ✦ Comet 21P/Giacobini-Zinner continues to brighten
- ✦ Explore the North America Nebula in our Deep-Sky Tour

JULY **HIGHLIGHTS**

Your guide to the night sky this month

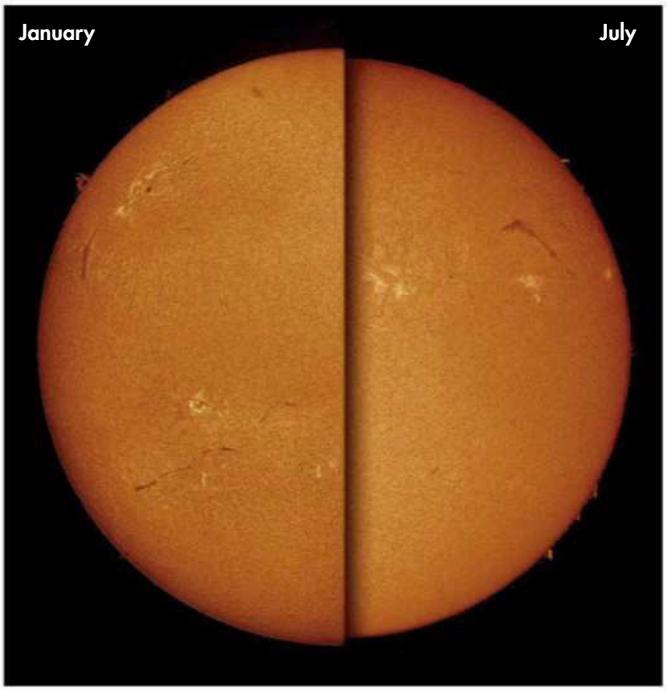


ALL MONTH

Noctilucent cloud season continues through July, so don't forget to keep a look out for these elusive, electric blue clouds, low in the northwest 90-120 minutes after sunset or low in the northeast a similar time before sunrise.

SUNDAY 1

Look out for the spectacular sight of mag. –2.2 Mars 3.9° below a 93%-lit waning gibbous Moon in the early hours of the morning. The best view will be from around 01:30 BST (00:30 UT).



◀ FRIDAY 6

Happy aphelion day! Today Earth reaches the point in its elliptical orbit when it is furthest from the Sun. Solar observers are presented with the smallest apparent Sun disc for the year.

SUNDAY 8

Venus is currently close to Regulus (Alpha (α) Leonis). Visible low in the west-northwest after sunset, the impressively bright, mag. –4.0 planet is closest to mag. +1.3 Regulus on 9 July when both objects will appear separated by a degree.

FRIDAY 13

The Moon is new today, meaning the night sky will be dark enough to try our Deep-Sky Tour on page 62. This month we're looking at the region close to the North America Nebula in Cygnus.

PETE LAWRENCE X 8

◀ MONDAY 23

Today is generally regarded as the start of the Perseid meteor shower. A bright Moon will hinder visibility at this point in the event, but the peak next month happens under extremely favourable conditions, occurring close to new Moon.

FAMILY STARGAZING – 27 JULY

The total eclipse of the Moon on 27 July is an ideal event for young observers as it occurs at the time of sunset. The rising Moon will be fully eclipsed and this will make it harder to see than normal. From the centre of the UK the Moon rises around 21:10 BST (20:10 UT) above the southeast horizon (exact time varies slightly with location). Make a game of seeing who can spot the eclipsed Moon first, and maybe encourage some sketching of the eclipse. Totality ends at 22:13 BST (21:13 UT) with the final partial phase continuing for the following hour. www.bbc.co.uk/cbeebies/shows/stargazing

SATURDAY 28

Look out for the just-past-full Moon close to brilliant Mars, which is currently shining away at mag. –8.

Jupiter appears to have an extra 'moon' – in fact the mag. +8.7 HIP 72182, located east of the planet near Europa and Callisto.

SUNDAY 29

Jupiter's extra 'moon' – the mag. +8.7 star HIP 72182 – now appears west of the planet.

◀ MONDAY 2

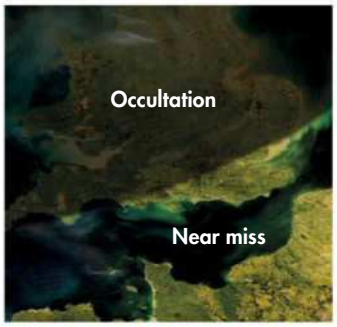
Mercury is currently visible low in the west-northwest after sunset. Although the twilight will make it difficult to see, the planet is currently buzzing past the Beehive Cluster, Messier 44, in Cancer.

THURSDAY 5

Lunar libration currently favours the Moon's western (illuminated) limb. Although not ideal for relief features, which rely on shadows to reveal detail, albedo features such as the dark lava at the edge of Mare Orientale should stand out quite well.

TUESDAY ▶ 10

A 13%-lit waning crescent Moon rises just left of Aldebaran (Alpha (α) Tauri) as seen from the centre of the UK just after 03:00 BST (02:00 UT), followed by a tricky-to-see grazing occultation of Gamma (γ) Tauri around 04:30 BST (03:30 UT).



THURSDAY 12

Mercury reaches greatest eastern elongation, separated from the Sun by 26.4° in the evening sky. Today the planet appears at mag. +0.6, low in the west-northwest after sunset.

SATURDAY 14

Mag. +0.7 Mercury is visible shortly after sunset low in the west-northwest with a slender 4%-lit waxing crescent Moon 1.8° to the right of it as seen from the UK.

SUNDAY 15

It's the turn of brilliant Venus to get a visit from the waxing Moon this evening. The 10%-lit crescent appears 4.5° from mag. –4.0 Venus in the evening twilight.

FRIDAY 20

This evening, a 61%-lit waxing gibbous Moon and mag. –2.0 Jupiter appear separated by a little over 4°.

TUESDAY 24

Mag. +0.6 Saturn sits 4° below and left of tonight's 92%-lit waxing gibbous Moon. The pair are due south at 23:00 BST (22:00 UT), located to the north of the Teapot asterism in Sagittarius.

FRIDAY ▶ 27

The rising full Moon will be totally shrouded by Earth's shadow, giving the UK its first total lunar eclipse since September 2015. This is also the smallest full Moon of 2018 – what is known as a Micromoon.

◀ TUESDAY 31

Jupiter's giant moon Ganymede will be casting its immense shadow down onto the planet's atmosphere from 21:54–23:39 BST (20:54–22:39 UT).

NEED TO KNOW

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

FAMILY FRIENDLY
Objects marked with this icon are perfect for showing to children

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

BINOCULARS
10x50 recommended

SMALL/ MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.

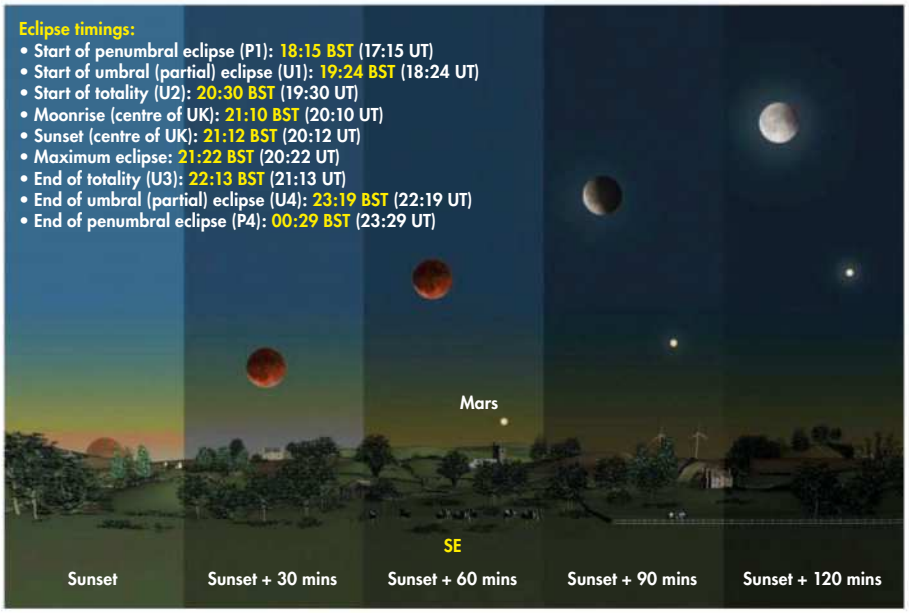
THE BIG **THREE**

The three top sights to observe or image this month

DON'T **MISS**

A total eclipse of the Moon

WHEN: 27 July from 21:10 BST (20:10 UT) until 23:40 BST (22:40 UT)



▲ **The smallest new Moon of 2018 will also be one of the most striking – a total lunar eclipse**

There is a total lunar eclipse this month, the first visible from the UK since September 2015. If the unthinkable happens and clouds ruin the fun, the next takes place during the early hours of 21 January 2019, so at least the wait isn't nearly as long. And while the UK will get to see the January 2019 eclipse from start to finish, this month's starts with the Moon well below the horizon.

The eclipse officially starts at 18:15 BST (17:15 UT) on 27 July, when the Moon enters the weak outer penumbral portion of Earth's shadow. As the Moon moves in towards the darker umbral shadow, its western surface will begin to darken. At 19:24 BST (18:24 UT), the Moon enters the umbral shadow and the partial phase of the eclipse begins. The umbral shadow creeps across the Moon's face until it completely covers it at 20:30 BST (19:30 UT), the start of totality. This is academic for the UK as it all happens before moonrise. To see these early phases of the eclipse you'll need to relocate somewhere, say, within Eastern Europe.

From the centre of the UK the Moon rises at sunset, making an appearance around 21:10 BST (20:10 UT), just before maximum eclipse at 21:22 BST (20:22 UT). This is the time when the Moon is deepest within the umbral shadow.

From the UK the dark Moon may initially be hard to see against the bright evening twilight. However, if the evening is clear it should be possible to see the dark, often red-orange coloured Moon embedded in the Belt of Venus. This is the name given to the pink band that stretches across the horizon opposite to the sunset, and it extends roughly 10–20° above the horizon. It represents the projection of the red sunset into Earth's atmosphere. Below it is a grey region which is the local version of Earth's shadow, projected into the atmosphere. The non-local version will be covering the Moon's face!

Totality ends at 22:13 BST (21:13 UT) with the Moon 6° above the southeast horizon from the centre of the UK. At this time the bright opposition planet Mars also makes an appearance, 5.9° below the Moon.

The second partial sequence ends at 23:19 BST (22:19 UT), almost an hour after the end of totality. The weak penumbral shadow continues to cross the Moon's face until 00:29 BST on 28 July (23:29 UT on 27 July). This part of the eclipse is difficult to see visually except when the Moon is near to the umbra.

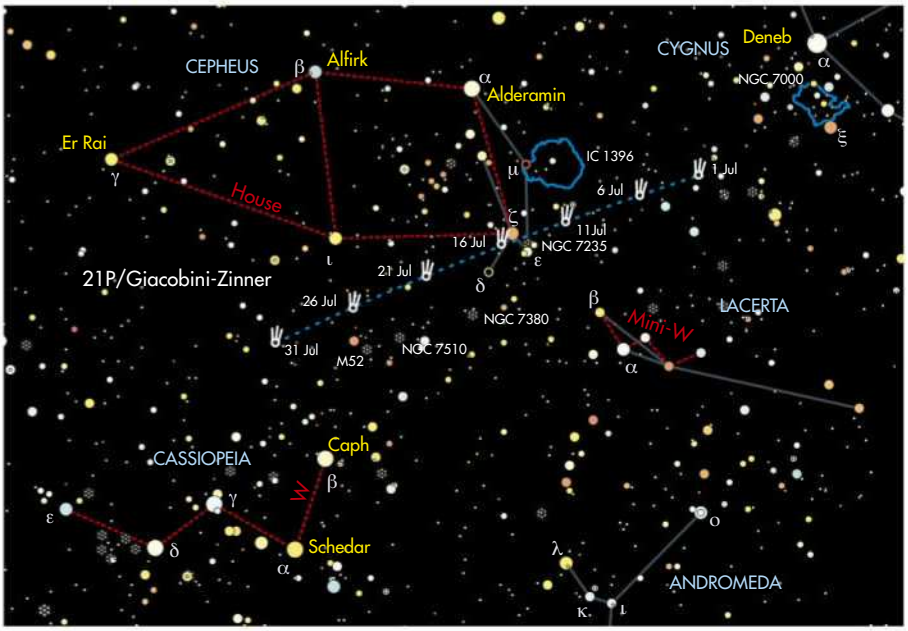
The full Moon which is eclipsed on 27 July will also be the smallest full Moon of 2018, being closest to apogee. This is unofficially described as a micromoon.

The fully eclipsed Moon will rise embedded in the Belt of Venus

PETE LAWRENCE X 4

Comet 21P/Giacobini-Zinner

WHEN: Throughout July, as described



▲ 21P/Giacobini-Zinner's July trek. Positions correct for 01:00 BST (00:00 UT) on dates shown

We've been keeping track of comet 21P/Giacobini-Zinner over the past couple of issues. Despite being a rather faint comet, it has been passing some interesting deep-sky objects. This month, 21P continues moving north, leaving the constellation of Cygnus, the Swan, and clipping the southeast corner of the House asterism in Cepheus before ending up close to the W-shaped constellation of Cassiopeia.

This is great news for UK viewing because this track keeps the comet visible all night long in an area of the sky relatively well positioned. In addition, the comet is expected to continue to grow brighter, increasing from mag. +10.9 at the start of the month, to mag. +8.9 by the end of July. This brings it within range of an average pair of binoculars.

The deep-sky photo-opportunities also continue as the comet appears to slip a couple of degrees east of the large nebulous region known as IC 1396 which sits south of the bottom of the House asterism. This passage occurs between 8-12 July and will make an interesting target for wide-field astrophotography. On the night of 13-14 July the comet will be less than 0.5° from the mag. +7.7 open cluster NGC 7234 before passing mag. +3.5 Zeta (ζ) Cephei by a similar distance on the following night.

Over the rest of the month, 21P heads along a path that will take it up the eastern wall of the House passing the clusters NGC 7380 (mag. +7.2), NGC 7510 (mag. +7.9) and M52 (mag. +6.9) by just a few degrees. The M52 passage occurs between 25-27 July but will be affected by the presence of a bright Moon in the sky.

On 31 July the brightening comet will slip into Cassiopeia, being located roughly midway between the famous W-shape and the House asterism.

Happy Aphelion Day

WHEN: 6 July, 17:46 BST (16:46 UT)

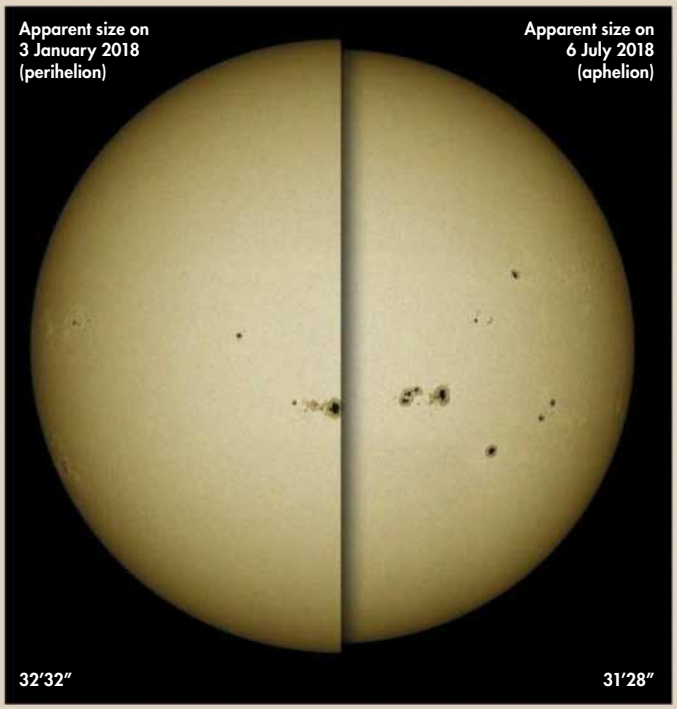
Earth will reach aphelion on 6 July at precisely 17:46 BST (16:46 UT). Although this will have no real noticeable effect on anyone's everyday life, it does make a difference to the view if you're into observing the Sun.

Aphelion is the term that describes when a body in elliptical orbit around the Sun is at its greatest distance from the centre of the Sun. At the point of aphelion, the distance between the centre of the Sun and Earth will be 152,095,566km. That's five million kilometres further than when Earth was at perihelion – the point when it's closest to the Sun – on 3 January 2018 when the distance was 147,097,233km.

This has a number of additional subtle effects. For one, the apparent size of the Sun in the sky reaches a minimum at aphelion. On 6 July the Sun's disc will appear 1,887.8 arcseconds across compared to 1,951.9 arcseconds at perihelion, a difference of 64.1 arcseconds or just over 1 arcminute.

The opposition of Mars at the end of the month also gets a slight boost, as we'll be further out from the Sun and closer to the orbit of the Red Planet. Mars itself is close to perihelion which also helps reduce the distance between our two worlds.

▼ On 6 July, Earth will be at its furthest from the Sun all year making the Sun appear at its smallest

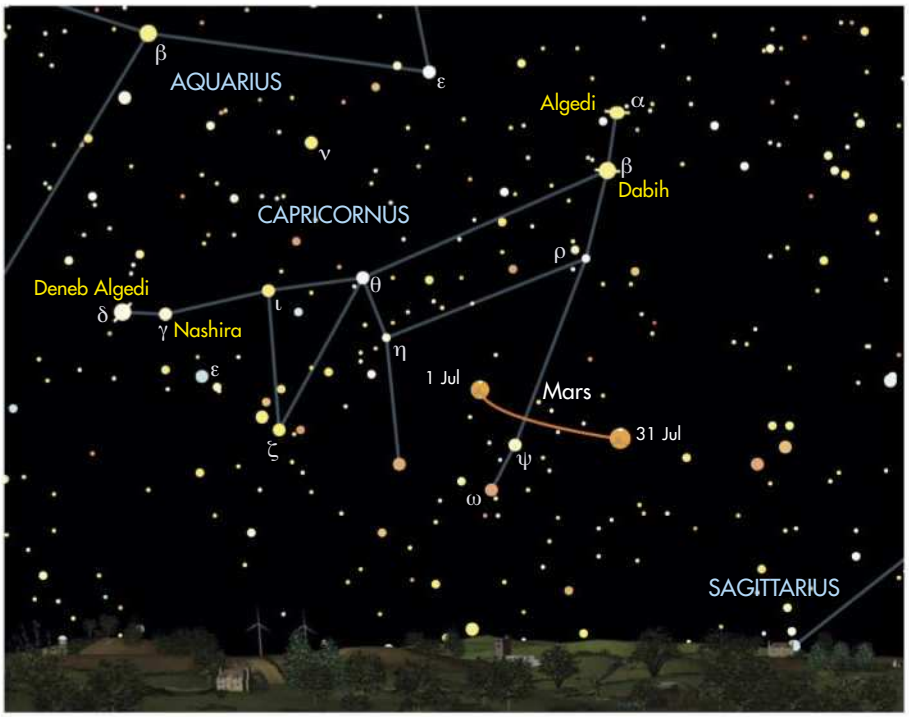


THE **PLANETS**

PICK OF THE MONTH

Mars

Best time to see: 28 July, 00:20 BST, (July 27, 23:20 UT)
Altitude: 11°
Location: Capricornus
Direction: South
Features: Light and dark surface regions, polar caps and weather
Equipment: 3-inch telescope or larger



▲ Mars in opposition will shine brightly in July but annoyingly it's also very low on the horizon

Mars reaches opposition on 27 July at which time the planet will be looking its largest and brightest. This particular opposition occurs when the planet is low in the sky from the UK. Mars will get to an apparent diameter of 24 arcseconds from 23 July through to 9 August, but reaches a maximum altitude of 11° as seen from the centre of the UK. Although this will add an extra challenge, take heart from the fact that for the next opposition on 13 October 2020, Mars will reach an altitude of 42° and will be only marginally smaller and less bright.

At the start of July 2018, Mars will appear to be travelling east against the stars, but by the end of the month its direction will have changed so that it appears to be moving west. Through a telescope it's the southern polar cap of Mars that's currently tilted towards us, by around 12°. The dark, V-shaped feature known as Syrtis Major is centrally placed at 01:00 BST (00:00 UT) on 2 July.

Mars rotates once on its axis every 24 hours and 40 minutes, which can lead to a degree of frustration when observing the planet. To explain this, imagine a feature centrally positioned on the planet's disc. At the same time the next day, the feature would appear in the central position 40 minutes later. The day after that it would reach the central position 80 minutes later than on the first night, and so on. Observing the planet at the same time on consecutive days essentially gives you a re-run of what you've been looking at on previous days!

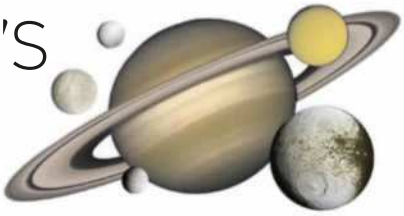
▲ The V-shaped Syrtis Major is one of the most easily recognised features on Mars

To the naked eye, Mars appears to brighten impressively throughout July, starting off at mag. –2.2, but increasing in brilliance to mag. –2.8 around opposition. This makes it brighter than Jupiter and the second brightest main planet after Venus.

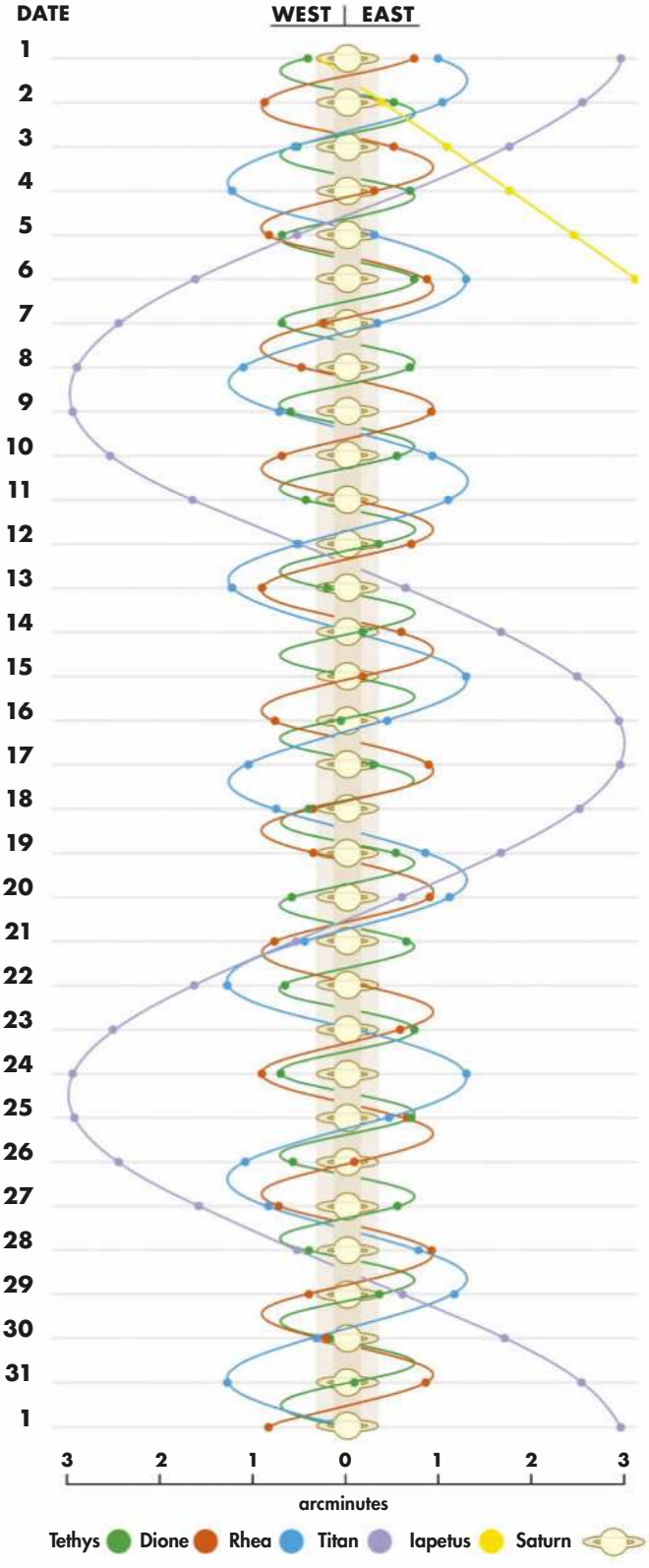
THE PLANETS IN JULY

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to match its orientation through a telescope

SATURN'S MOONS JULY



Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



Mercury

Best time to see: 7 July, 30 minutes after sunset
Altitude: 5° (low)
Location: Cancer
Direction: West-northwest

Mercury is reasonably well positioned at the start of July. It approaches greatest eastern elongation on 12 July when it appears 26.4° from the Sun in the evening sky. It starts the month at mag. +0.1 then dims slowly to around mag. +1.0 by 19 July. Mercury's position deteriorates after greatest elongation and by 19 July it sets roughly 45 minutes after the Sun. From then on, it'll be lost from view for the rest of the month.

Venus

Best time to see: 1 July, 22:15 BST (21:15 UT)
Altitude: 12°
Location: Leo
Direction: West-northwest

Despite approaching greatest eastern elongation from the Sun, the circumstances for viewing Venus in the evening sky deteriorate in July. This is because of the ever-flattening angle the ecliptic makes with the western horizon after sunset. On 9 July, the mag. –4.0 planet sets two hours after the Sun and sits 1° from mag. +1.3 Regulus (Alpha (α) Leonis). As greatest eastern elongation approaches, the planet's apparent size increases while its phase decreases. On 31 July, Venus appears 20 arcseconds across through a scope with a phase just over half-lit at 57%.

Jupiter

Best time to see: 1 July, 22:40 BST (21:40 UT)
Altitude: 20°
Location: Libra
Direction: South-southwest

Jupiter has been hit by bad timing relative to the June solstice this year and now appears well to the west of south as the sky darkens. The mag. –2.1 planet is still prominent, but for telescopic viewing its lower altitude affects fine detail. A 61%-lit waxing gibbous Moon sits nearby on the night of 20 July. Jupiter's observing window deteriorates throughout the month, the planet being 11° up as seen from the centre of the UK, low in the southwest as darkness falls on 31 July.

Saturn

Best time to see: 1 July, 01:00 BST (00:00 UT)
Altitude: 14°
Location: Sagittarius
Direction: South

Saturn is currently located north of the Teapot asterism at the centre of Sagittarius. It appears like a yellow-hued star of mag. +0.4 on 1 July. A bright waxing gibbous Moon approaches from the west on the evening of 24 July. At the end of July, the mag. +0.6 planet reaches its highest point due south, as the sky begins to get dark but loses altitude during true darkness.

Uranus

Best time to see: 31 July, 02:15 BST (01:15 UT)
Altitude: 24°
Location: Aries
Direction: East-southeast

Uranus is visible this month, 9° north of Alrescha (Alpha (α) Piscium). Although it has been located in Pisces over previous years, the mag. +5.8 planet has currently moved into neighbouring Aries.

Neptune

Best time to see: 31 July, 02:15 BST (01:15 UT)
Altitude: 27°
Location: Aquarius
Direction: South-southeast

Mag. +7.8 Neptune has been creeping back into view over the past few weeks but thwarted by the short nights at this time of year. At the end of July, it can be seen under dark conditions but doesn't quite manage to attain its highest position in the sky in darkness.

YOUR BONUS CONTENT Planetary observing forms

THE NORTHERN HEMISPHERE IN JULY

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Cirdel — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

- COMPASS AND FIELD OF VIEW

MILKY WAY

WHEN TO USE THIS CHART

1 JULY AT 01:00 BST
15 JULY AT 00:00 BST
31 JULY AT 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

SUNRISE/SUNSET IN JULY*

DATE	SUNRISE	SUNSET
1 Jul 2018	04:45 BST	21:41 BST
11 Jul 2018	04:55 BST	21:35 BST
21 Jul 2018	05:08 BST	21:23 BST
31 Jul 2018	05:23 BST	21:07 BST

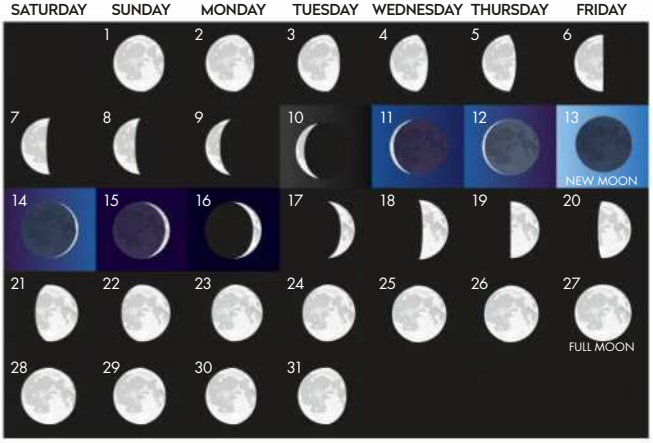
MOONRISE IN JULY*

MOONRISE TIMES

1 Jul 2018, 23:35 BST	17 Jul 2018, 10:43 BST
5 Jul 2018, 00:42 BST	21 Jul 2018, 15:40 BST
9 Jul 2018, 02:09 BST	25 Jul 2018, 19:44 BST
13 Jul 2018, 05:20 BST	29 Jul 2018, 22:05 BST

*Times correct for the centre of the UK

LUNAR PHASES IN JULY



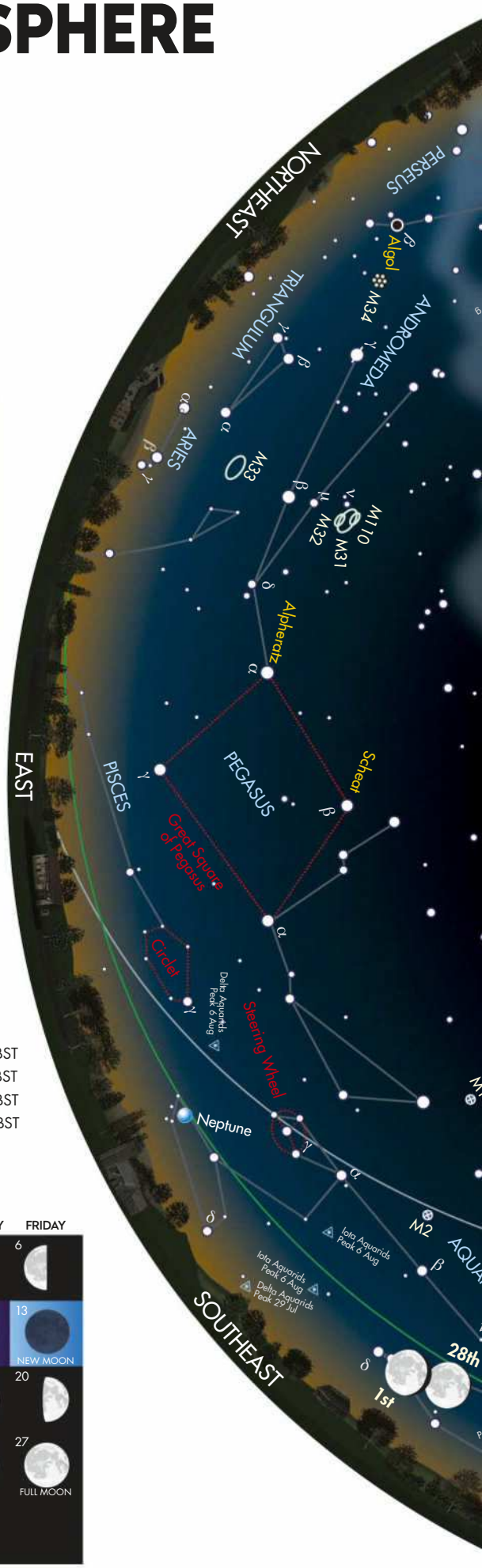
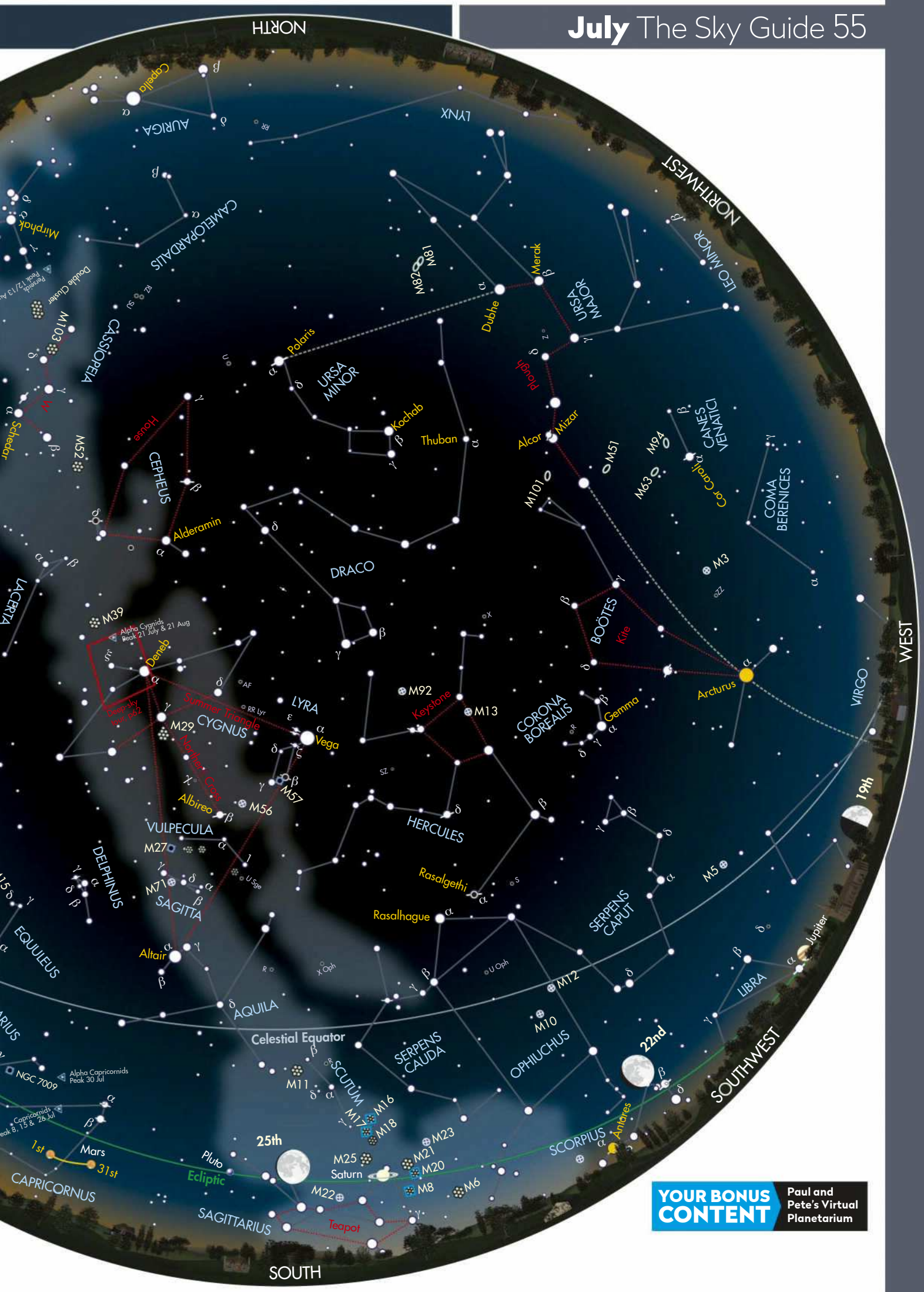


CHART: PETE LAWRENCE

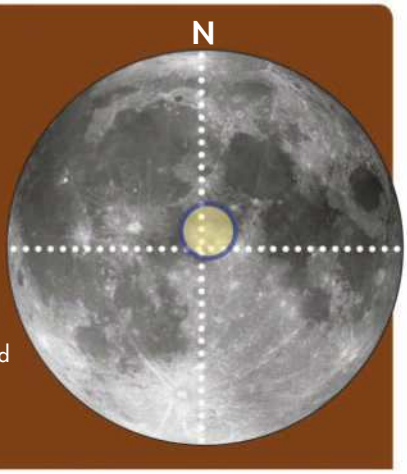


YOUR BONUS CONTENT Paul and Pete's Virtual Planetarium

MOON**WATCH**

Ukert

Type: Crater
Diameter: 23km
Longitude/latitude: 1.4° east, 7.7° north
Age: 3.8-3.85 billion years
Best time to see: Six days after full Moon (4-5 July) or first quarter (20-21 July). Lunar X and V will next appear on 18 August around 18:30 BST (17:30 UT)
Minimum equipment: 2-inch refractor



Ukert is a small, 23km diameter crater, located mid-way between Mare Vaporum and Sinus Medii. Actually, diameter isn't quite the correct term here because Ukert looks more like an equilateral triangle with bulging edges. Interestingly, the three 'edges' appear to be connected by ridges running from their midpoints to a central peak.

Ukert stands out against the rough terrain between Vaporum and Medii. There is a curious linearity to the roughness, which seems to run in parallel striations from northwest to southeast. The 26km crater **Ukert M**, located immediately east of Ukert, creates a marked interruption within these linear features. Despite its similar size, Ukert M lacks the carved-out rim of Ukert, and simply resembles a flattened area within the rough terrain.

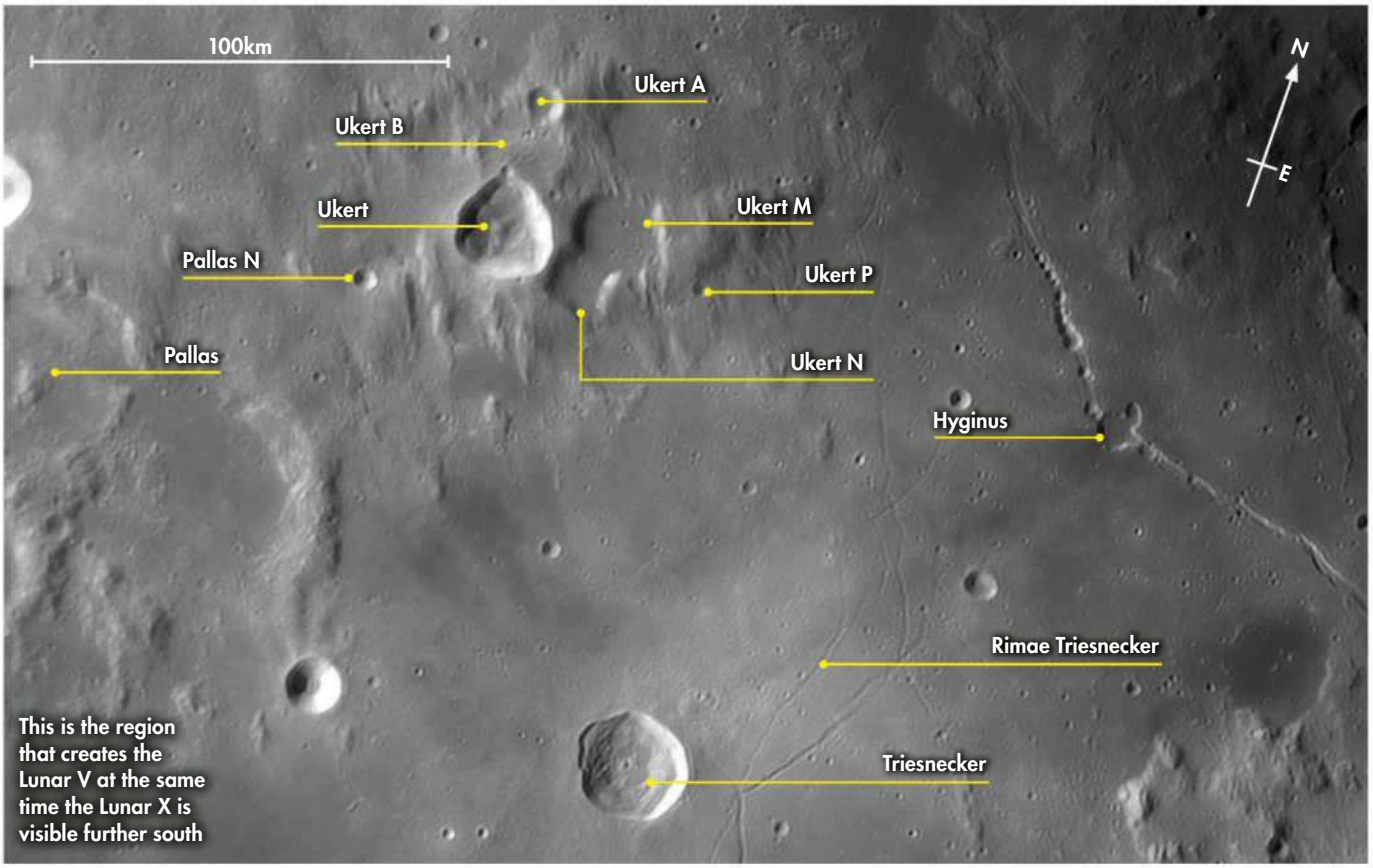
A number of smaller craters lie nearby, with 9km **Ukert A** to the north and 5km **Ukert P** to the east. A 6km crater, located 20km to the southwest, is actually **Pallas N,** a satellite of 50km **Pallas**, which lies 110km southwest of Ukert.

For a real challenge, try to spot the tiny 3.5km crater that sits at the northern vertex of Ukert's triangular shape. The region between Ukert and Ukert A is defined as the 21km crater **Ukert B**, but it is quite indistinct.

Despite its diminutive size, Ukert is given a boost in notoriety around the first quarter phase because it forms part of the 'clair-obscur' (or exaggerated shadow) effect known as the Lunar V. This forms at the same time as the better-known Lunar X, both of them created when the advancing morning terminator illuminates certain elevated features to produce X and V shapes that appear to float against the darker, shadowed surface below. The eastern arm of the V is largely formed from the elevated feature that runs from the northeast edge of Ukert M to the northeast. The point of the V is formed by the elevated region that runs along the east and south of 17km **Ukert N**, a flat-floored crater conjoined to Ukert M. The western arm then begins with the illuminated eastern rim of Ukert extending towards the north. A pair of high ridges completes the main section of the V's western arm.

When the V is visible, there's also a wealth of detail nearby. To the southeast is 27km **Triesnecker**, only partially illuminated. To the east is a complex set of cracks in the lava known as **Rimae Triesnecker**. They are among the most intricate and extensive rille systems on the lunar surface and well worth catching under oblique illumination.

"For a challenge try to spot the tiny 3.5km crater on Ukert's northern tip"



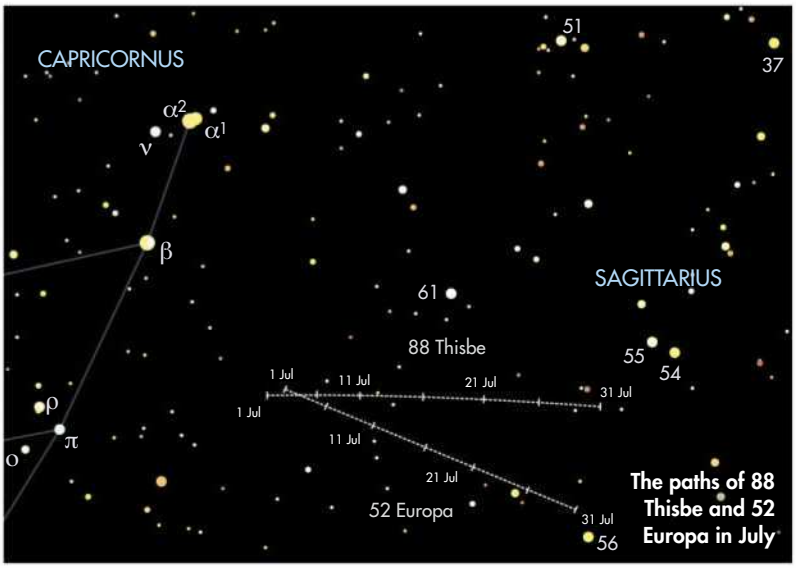
PETE LAWRENCE X 3

COMETS AND **ASTEROIDS**

Keep track of two asteroids that are practically travelling companions throughout July

The paths of Asteroids 52 Europa and 88 Thisbe cross early in the month, then later they both reach opposition on 20 July, making them an ideal pair to keep a track of.

52 Europa brightens from mag. +11.4 on 1 July to mag. +11.0 at opposition, diminishing to mag. +11.3 by 31 July. Similarly, 88 Thisbe brightens from mag. +10.2 to +9.7 around 20 July, dimming only slightly to +9.9 by the end of the month. As a result, 88 Thisbe is a good target for smaller instruments but 52 Europa is more of a challenge, especially given the relatively low altitude patch of sky the pair will be occupying.



The paths of 88 Thisbe and 52 Europa in July

52 Europa is a large, main belt carbonaceous, or C-type, asteroid that takes 5.46 years to orbit the Sun. It's the sixth largest asteroid by volume and, like many asteroids, it's not spherical; rather it's a 'triaxial ellipsoid', with principal dimensions of 379x330x249km. 88 Thisbe, meanwhile, is the 13th largest of the main belt asteroids with a diameter of around 225km. Again, it's not spherical, with principal dimensions measuring 255x232x193km. It takes 4.6 years to orbit the Sun and is an uncommon kind of carbonaceous asteroid categorised as B-type. These tend to be slightly brighter than the dark C-types like 52 Europa.

Both asteroids start the month near the western border of Capricornus. At 01:00 BST (00:00 UT) on 1 July they appear separated by about 22 arcminutes. They maintain a similar degree of separation on the following nights, only starting to show increased distance on the morning of 6 July when 52 Europa will have slipped across the border into Sagittarius. 88 Thisbe follows suit two mornings later. Their paths continue to diverge after this, their apparent separation increasing to 2° at 01:00 BST (00:00 UT) on 31 July.

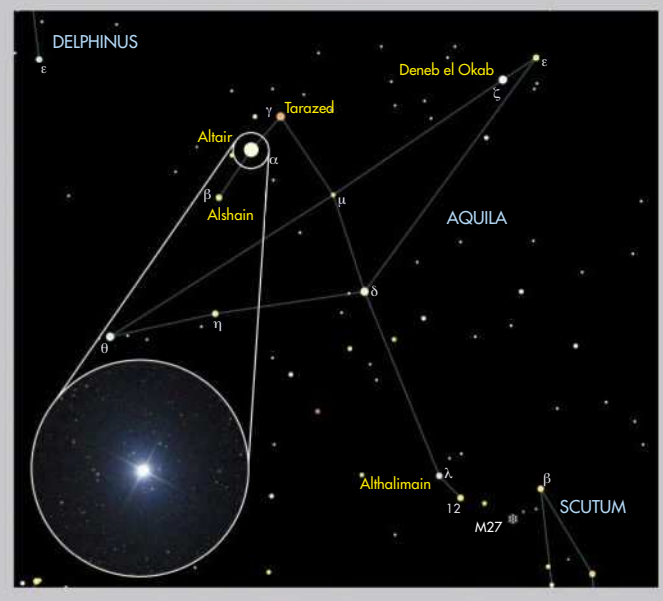
STAR OF **THE MONTH**

Part of both Aquila and the Summer Triangle, Altair is a fascinating multitasker

Altair is the brightest star in the constellation of Aquila, the Eagle. It also marks the southern vertex of the large and distinctive asterism known as the Summer Triangle and is itself distinctive because of two dimmer stars that appear to sit on either side of it. These are mag. +2.7 Tarazed (Gamma (γ) Aquilae) to the north-northwest, and mag. +3.7 Alshain (Beta (β) Aquilae) to the south-southeast. Blazing away at mag. +0.8, Altair easily outshines both of them and together the trio are known as the 'Shaft of Aquila'.

Altair is a relatively close neighbour to the Sun, lying at a distance of 16.7 lightyears. It has three fainter companions located under 200 arcseconds distant from it. The multiple star designation of Altair is WDS 19508+0852A with the companions ending in B, C and D. Mag. +9.8 B (192.1", PA 287°) is not gravitationally connected with Altair (A), having a purely line-of-sight proximity. The other two stars are mag. +10.3 C (189.6", PA 107°) and mag. +11.9 D (31.7", PA 97°).

Physically Altair's radius is 1.8 times larger than our Sun's with a luminosity 10.6 times greater. Its close proximity has allowed its apparent disc size to be directly measured as 3 milliarcseconds. Compared to the Sun, Altair is a fast rotator, spinning once on its axis every 8.9 hours. This causes the equatorial regions of the star to bulge outwards and results in an effect known as gravity darkening where the equatorial diameter is 25% larger than the polar diameter. The spin axis is inclined to our line of sight by around 60°.



▲ **Altair, like Summer Triangle companion Vega, has a tubby equator**

Of the three stars in the Summer Triangle, Altair is physically the dimmest. Mag. +0.0 Vega outshines it despite lying over eight lightyears further away. The visually dimmest star to our eyes is mag. +1.25 Deneb. However, Deneb is estimated to be around 2,600 lightyears away, so in reality it is very luminous indeed.

STEPHEN TONKIN'S
BINOCULAR **TOUR**

Let's see what stands out against even a backdrop of the Milky Way's densest area

☑ Tick the box when you've seen each one

1 M11

10x 50 There are hundreds of open clusters in the southern Milky Way and we begin this month's tour with one of the richest. About 2° southeast of mag. +4.2 Beta (β) Scuti, you should see, spanning about 0.25° of sky, what could be mistaken for an unresolved globular cluster. This is the glow of over 2,000 young, blue stars that form the Wild Duck Cluster. Were this not the densest known open cluster, you'd have trouble identifying it as lies against the Milky Way's densest region, the Scutum Star Cloud. ☐ **SEEN IT**

2 M16

15x 70 To find M16, the Eagle Nebula, put mag. +4.7 Gamma (γ) Scuti at the southeast of the field of view and the cluster will be just west of centre. Unless you have pristine skies and a UHC or O-III filter, don't expect to see even a hint of the 'Pillars of Creation' made famous by the Hubble Space Telescope image. In unfiltered binoculars, you will probably only be able to see the cluster, but the filter could reveal the nebulous shape of the wings and tail from which this object gets its common name. ☐ **SEEN IT**

3 M25 AND UPSILON (υ) SAGITTARII

10x 50 If you navigate 4.5° south from Gamma Scuti you should easily find the bright (mag. +4.6) open cluster M25 against the background Milky Way, with eight or so stars resolved against a grainy background. This is an unusual open cluster in that it has few blue-white stars. Embedded in it is the white Cepheid variable star, Upsilon (υ) Sagittarii, which varies between mag. +6.3 and mag. +7.2 over 6.75 days. The absolute magnitude of a Cepheid can be established from its period, enabling them to be used as 'standard candles' for establishing astronomical distance scales. ☐ **SEEN IT**

4 M24

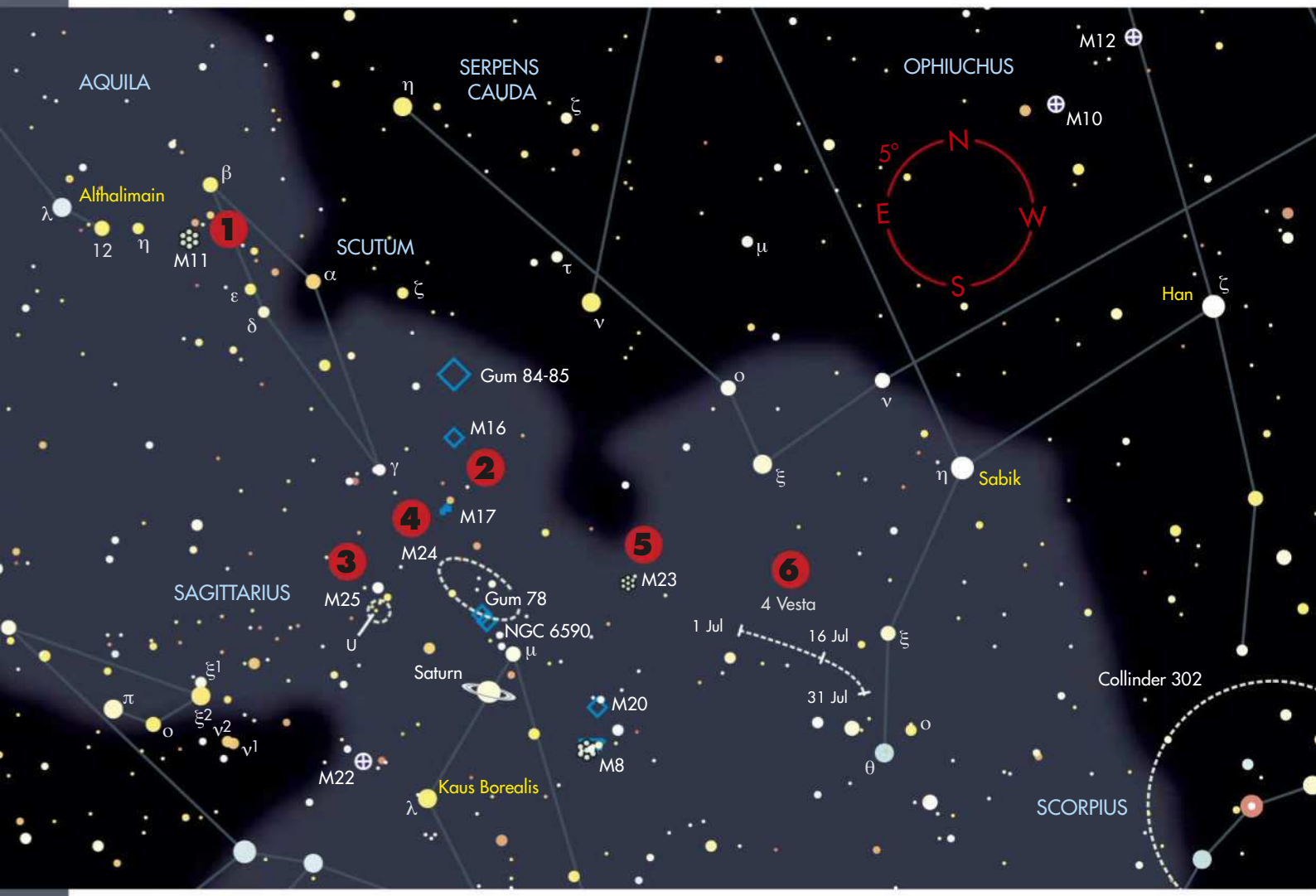
10x 50 The Sagittarius Star Cloud, M24, lies slightly more than halfway from Gamma Scuti to Mu (μ) Sagittarii. It is a bright patch of light easily visible to the naked eye and which, from Britain, can easily be mistaken for a small cloud just above the horizon. Even tiny compact binoculars begin to reveal detail and it is easily the richest vista visible in 10×50s, with around 1,000 stars being resolved in a single field of view! The darker parts are not an absence of stars, but obscuring dust. ☐ **SEEN IT**

5 M23

15x 70 M23 is just over halfway from Xi (ξ) Serpentis to Mu (μ) Sagittarii, but may be difficult to distinguish from the rich background of the Milky Way. However, this bright (mag. +6.7) oval open cluster is an exquisite object in 70mm binoculars, which reveal about a dozen stars in the shape of a lower case alpha (α) against the background glow of another 140 fainter stars. M23 evolved at the same time as the first dinosaurs (about 220 million years ago), and is only 2,150 lightyears from Earth, which is why it appears relatively large (15×27 arcminutes). ☐ **SEEN IT**

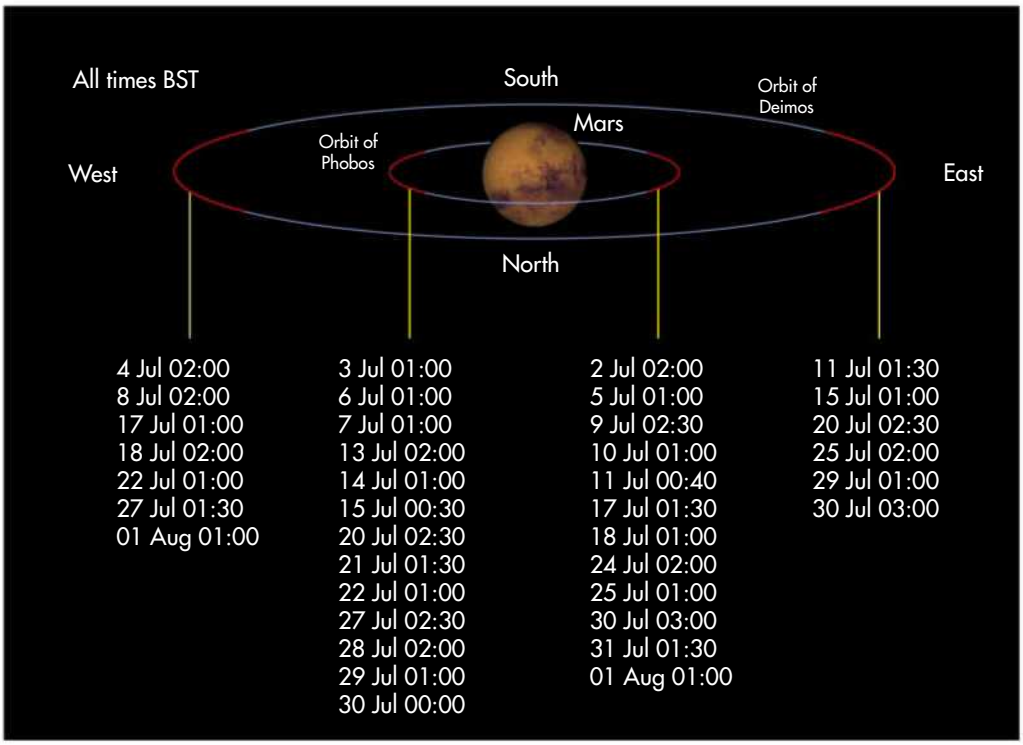
6 VESTA

10x 50 Asteroid 4 Vesta spends July moving along a 4° curved path that begins about 9° southeast of the mag. +2.5 star Sabik (Eta (η) Ophiuchi). Currently at mag. +5.6, and fading to mag. +6.3 during July, Vesta is a very easy binocular object which you should have no difficulty identifying and following. ☐ **SEEN IT**



THE SKY GUIDE **CHALLENGE**

Although Mars is a near neighbour, capturing its moons is surprisingly tricky but rewarding



▲ **A list of upcoming elongations for both Phobos and Deimos – these will be the best times to capture them**

One of the defining moments when you first look through a telescope at the planet Jupiter is seeing its four largest moons shining like tiny diamonds as they orbit their parent planet. Saturn's brightest moons also have this wow effect, especially the large, dense atmosphere-shrouded Titan. Further in towards the Sun, Mars has two moons, Phobos and Deimos, but they are not easy to see, let alone photograph. This month's challenge is to image them.

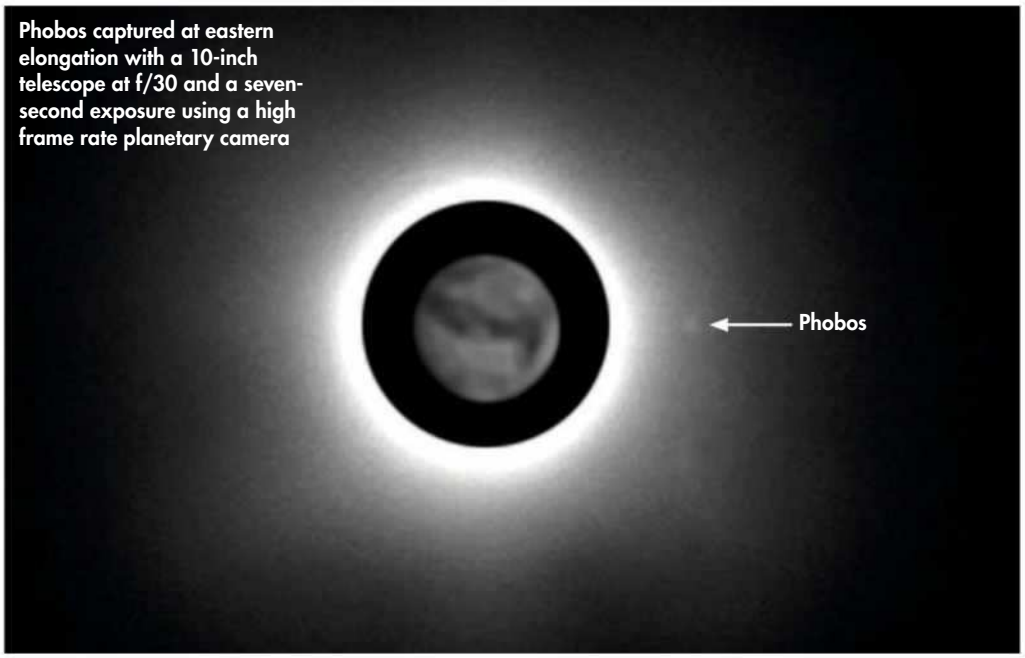
Both Martian moons are tiny objects. Phobos is the largest measuring 27x22x18km. It orbits Mars every 7.5 hours at a distance of approximately 9,300km. Through a telescope during July, Phobos achieves an apparent separation from the centre of Mars of 33 arcseconds. During the period around opposition, Phobos should be around mag. +10.5. Although this isn't a particularly challenging magnitude for amateurs to detect visually or photographically, the moon's close proximity to Mars is an issue. The glare of the mag. –2.8 Red Planet can easily swamp the dim Phobos.

Deimos fares slightly better thanks to its increased distance from Mars. This moon has dimensions of 15x12x11km, roughly half the size of Phobos. It orbits at a distance of 23,460km from the centre of Mars and at opposition can reach mag. +11.6 with an apparent separation of 1.4 arcminutes. The orbital period of Deimos is 1.26 days.

Viewing the moons typically requires larger apertures, while using an occulting bar can help enormously; this is an optical obstruction in the focal plane of the eyepiece behind which you can hide the planet to make the moons easier to spot. People tend to make their own from card or foil as, oddly, they're not widely commercially available.

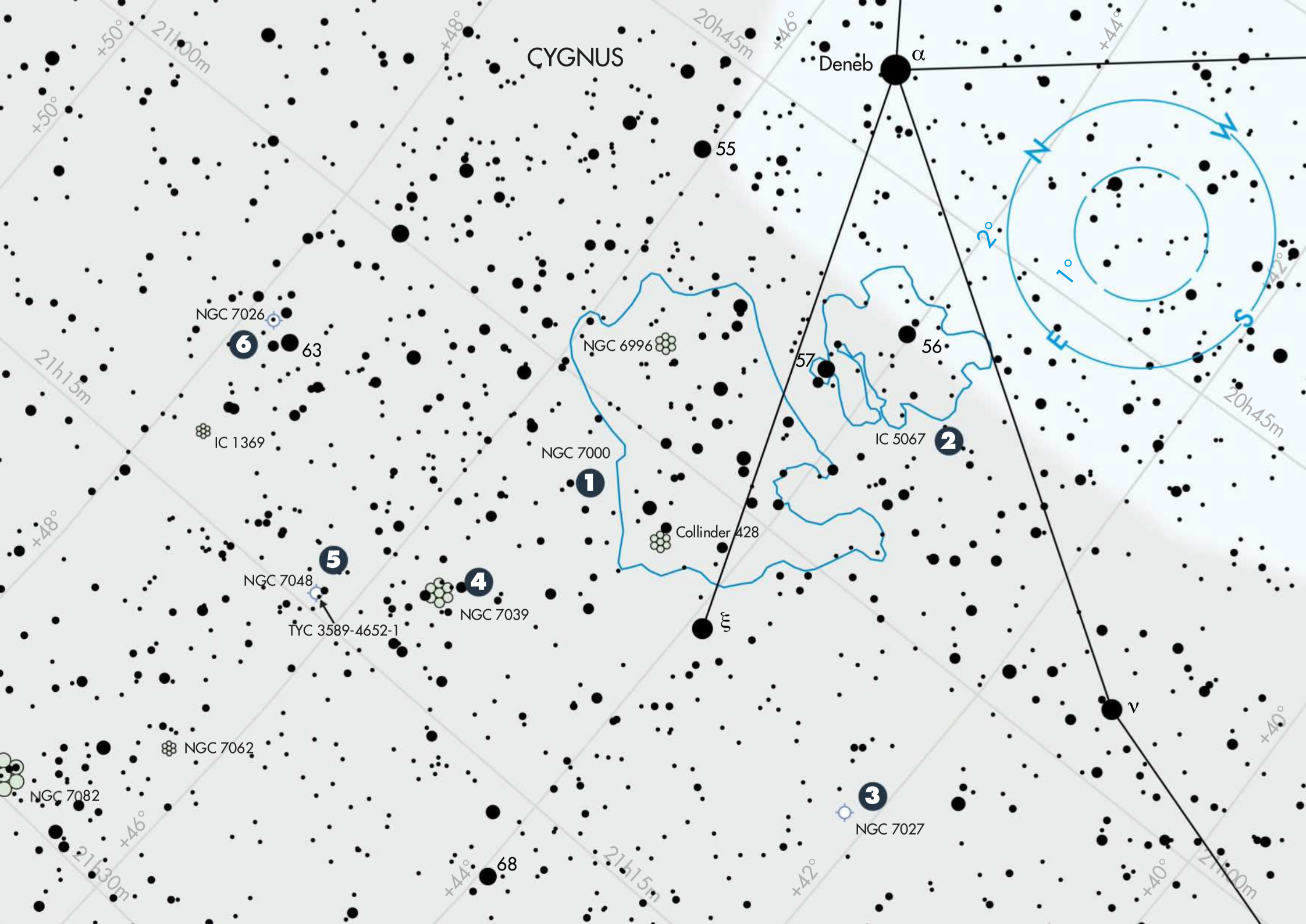
Photographically, a long effective focal length in excess of 8m is required. A high frame rate camera should be able to capture both moons but exposures may need to be pushed into the multi-second range. Clear, moisture-free optics help reduce the spread of glare from the planet and it's recommended to choose a night when the seeing is relatively still, which is a challenge in itself considering Mars's low altitude.

It's essential to try to image the moons when they're close to an elongation and appear furthest from the planet. We've listed some elongation times (left) to help. A number of smartphone apps may also provide this information and there's always the excellent freeware PC program WinJupos to help plan observations. It normally takes a bit of digging within each image frame to see the faint dot of a Martian moon but there's a huge sense of satisfaction when you eventually do manage to capture one. Taking multiple captures and animating them together can make the moons easier to detect.



Phobos captured at eastern elongation with a 10-inch telescope at f/30 and a seven-second exposure using a high frame rate planetary camera

PETE LAWRENCE X 3


CYGNUS
Deneb
α
55
56
57
63
ξ
ν
NGC 7026
NGC 6996
IC 1369
NGC 7000
IC 5067
Collinder 428
NGC 7048
TYC 3589-4652-1
NGC 7039
NGC 7062
NGC 7082
NGC 7027
68
1
2
3
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5
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2°
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S
+50°
+48°
+46°
+44°
+42°
+40°
21h00m
20h45m
21h15m
21h30m

DEEP-SKY TOUR

Take a swan dive into the nebulae nestling to the northwest of Cygnus

☑ Tick the box when you've seen each one

1 NGC 7000

We start this month's tour with the North America Nebula, NGC 7000, so called because its shape resembles that of the North American continent. This is a large object measuring 120x100 arcminutes and consequently a difficult target for telescopes. Located 3° east of Deneb (Alpha (α) Cygni), it's just about visible to the naked eye from a dark-sky site. NGC 7000 contains a multitude of stars and star clusters all embedded within its glowing nebula. The brightest region around the 'Gulf of Mexico' is referred to as the Cygnus Wall and it is the most likely part of the nebula to be visible through a small telescope using a low-power eyepiece. The nebula's distance isn't precisely known but is thought to be in excess of 1,600 lightyears away. ☐ **SEEN IT**

2 IC 5067

IC 5067 is located immediately west of NGC 7000. It is known as the Pelican Nebula because it resembles the appearance of an east-facing pelican in photographs. This is visually trickier to see than its continental companion, the easiest part being the area containing the head and beak, which lies 15 arcminutes off the east 'coast' (ie, west) of NGC 7000. The Pelican and North America Nebulae are part of the same glowing hydrogen gas cloud, their distinctive shapes created by a dark foreground molecular cloud. Binoculars or a small telescope at 15x-20x magnification and fitted with a UHC filter should provide you with a decent view of NGC 7000 as well as the Pelican's head. ☐ **SEEN IT**

3 NGC 7027

Our next target is planetary nebula NGC 7027, located 1.7° south and 0.4° east of mag. +3.7 yellow-orange Xi (ξ) Cygni, itself located just east of NGC 7000. This mag. +10.4 planetary has an apparent diameter of 14 arcseconds. Through a 6-inch scope at 50x magnification it resembles a dim 9th magnitude star. Increased power shows an oval shape with larger apertures revealing a green-hued planetary that looks vaguely rectangular. Thanks to the Hubble Space Telescope we now know this is a planetary nebula in the very early stages of development, around 600 years old. NGC 7027 is one of the smallest planetary nebulae known, measuring less than 0.2 lightyears across. The central star shines at mag. +16.3. ☐ **SEEN IT**

4 NGC 7039

Now head to a location 2° north-northeast of Xi (ξ) Cygni. Here you'll find the 8th magnitude open cluster NGC 7039. You might think that finding a mag. +7.6 open cluster would be a relatively easy task but, sadly, that's not the case in this instance. The issue here is not the brightness of the open cluster but rather the star-rich nature of the surrounding sky – it's like stellar camouflage. The 100 or so members of the cluster simply blend into their surroundings far too well! The cluster appears to be about 25 arcminutes across and is mostly populated by stars between magnitudes +11 and +13. A few brighter members appear to border the central core. Use a low power to see NGC 7039 at its best. ☐ **SEEN IT**

◂ Mag. +12.1 NGC 7048 may be faint, but this unusual planetary nebula is worth the effort you need to put in to observe it

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

5 NGC 7048

Next up is planetary nebula NGC 7048. This is the faintest of this month's tour objects shining away with an integrated magnitude of +12.1. Combined with a reasonable apparent diameter of around 1 arcminute, NGC 7048's surface brightness is quite low and this makes it something of a challenge to observe. Consequently you'll need a telescope with at least 10-inches of aperture. It sits 45 arcminutes northeast of NGC 7039 and there's a mag. +10.5 star (TYC 3589-4652-1) just southeast of the nebula's centre. At higher powers, the nebula appears like a faintly glowing disc with the outer edge appearing as broken arcs. The internal 'surface' of the disc appears distinctly mottled with averted vision. ☐ **SEEN IT**

6 NGC 7026

Our final object for this month's tour is NGC 7026, another planetary nebula. We've already had a look at the rectangular NGC 7027 and the circular NGC 7048 but NGC 7026 is more irregular in appearance. It's a bipolar nebula with two roughly symmetrical, elongated lobes, their long axes parallel to one another. The nebula is known as the Cheeseburger Nebula because the lobes are separated by a dark lane that resembles the filling of a burger. It shines at mag. +11 and appears around 25 arcseconds across. Larger apertures at high powers reveal that the 'cheeseburger' is surrounded by a glowing haze. The 'buns' also show brighter patches at high magnification. NGC 7026 is located 2° northwest of NGC 7048. ☐ **SEEN IT**

YOUR BONUS CONTENT

Print out this chart and take an automated Go-To tour

CHART: PETE LAWRENCE, PHOTO: MICHAEL BREITE/ STEFAN HEUTZ/ WOLFGANG RIES/CCDGUIDE.COM

ASTROPHOTOGRAPHY

The lunar eclipse will already have reached totality when the Moon rises in the UK on 27 July, which brings its own photographic challenges

Photographing a lunar eclipse

RECOMMENDED EQUIPMENT

DSLR, 200mm or longer focal length lens or a telescope

THE BIG PICTURE

BE AWARE THAT NOT ALL LUNAR ECLIPSES ARE ALIKE

There's a lunar eclipse this month, the first since 2015. While not rare, their infrequent nature and the possibility of unfavourable weather raises the stakes when attempting to photograph them. To complicate matters, the Moon will be in full eclipse as it rises as seen from the UK, and this will mean that you'll need to push your twilight imaging skills to the full. As each eclipse is different in terms of darkness, it's imperative you master your camera's review screen and all the information it's capable of delivering. Preparation is definitely the key to enjoying this impressive celestial event.

This month's total lunar eclipse should, if the weather is kind, be a spectacular event. From the UK, the Moon will rise fully immersed in the Earth's shadow and this will add an extra layer of challenge to the proceedings.

The reason is that a total lunar eclipse can only occur at full Moon and this one rises as the Sun sets on the opposite horizon. Consequently, the sky will be in a transitional twilight state during the eclipse. This requires you to photograph against an ever-changing sky background so you'll need concentration and dexterity to succeed. A bright sky and potentially dark Moon may make the eclipse difficult to see just after moonrise.

The dynamic range of an eclipsed Moon is another aspect which needs careful treatment. While the human eye is superb at delivering a view that fully incorporates both the bright and shadowed lunar surface during the partial phase of the eclipse, a camera struggles.

You also need to consider image scale, or how large the Moon will appear in your shots. This is determined by the focal length of the lens or telescope you have attached to the camera. If you're using a focal length that gives an appreciable scale, consider using a tracking mount to avoid motion blur and having to track the Moon manually.

It is important to determine the location where the Moon will first appear as this can really catch you out. If you're up in the early hours on the mornings before the eclipse it's worth noting that mag. +2.0 Deneb Kaitos (Beta (β) Ceti) rises 3.5° to the left of where the Moon will rise on the evening of 27 July. If you have your eclipse viewing site worked out, determine where this star comes up and this will give you an estimate of the direction you need to be looking on eclipse day. For reference, from the centre of the UK, Deneb Kaitos rises at 01:42 BST (00:42 UT) on 20 July and four minutes earlier each subsequent morning, or four minutes later on each previous morning.

Bear in mind that a shot of the eclipsed Moon with the horizon in view gives more visual impact and context. Unless the air is exceptionally clear down to the horizon, this typically means a shorter focal length will be needed to provide a larger field of view. This will allow you to get the Moon above the horizon after the it has achieved altitude.

Another consideration is how often you intend to photograph. If you want to grab a shot every 30 seconds for example, this creates a lot of stress, especially if things go wrong. Relaxing the regime to taking a shot every one or two minutes, makes life a lot easier.

Finally, consider what impression of the partial phase you want to capture. A shot of the Moon's bright surface with the shadowed region looking dark? Or one that shows detail in the shadowed region but over-exposes the bright surface?

With so many decisions to make it's worth remembering that you should try to enjoy watching some of the event too. Create a shooting plan and stick to it. On the days before make sure that all your equipment is working and easy to transport and assemble. Ultimately, the best advice is not to overload yourself with too much to do!

✉ Send your images to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

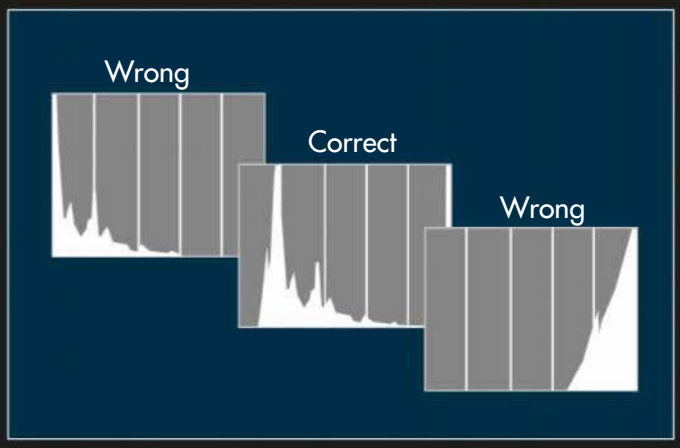
STEP BY STEP

STEP 1

Decide beforehand what type of shot you're after. Select a telescope or lens to give you the correct field of view. The Moon's diameter is about 0.5°. A non-full frame camera using a 200mm lens gives a frame size of 6.3°x4.2°. 300mm gives 4.2°x2.8°. A 1,000mm focal length gives a good close-up but tracking is highly recommended at such scale.

STEP 2

Set the camera and lens, if you are using one, to manual [M] mode. Set the ISO to a low value to start, say ISO 200-400. Set the f/number to f/8-f/11. Pre-focus at infinity. Pre-focusing the night before is a good idea as long as you're careful not to alter the focus. If possible use your camera's RAW format for the best results.



STEP 3

Set a short exposure, say 1/1000 second. Take a test shot just before sunset, then review the image and take a look at the image histogram. Ideally, the histogram will show a 'mountain' graph contained between the two extremes of the histogram. An under- or over-exposed image will truncate at one of the histogram edges.

STEP 4

If the image is too dark, lower the f/number. If you reach the lowest value, start to increase exposure. Pushing the ISO higher helps too but be wary of creating too much noise. For this reason, review each shot after each settings change. For an over-exposed image increase the f/number, reduce the ISO or shorten the exposure to compensate.

STEP 5

For the totally eclipsed Moon, attempt to record detail in the dark umbral shadow. Be careful not to over-expose, though. During the partial phase, over-exposure is acceptable if you want detail in the shadowed region, otherwise aim to get a bright but not over-exposed surface for a more realistic image.

STEP 6

Post eclipse, review your shots and pick the best ones. A gentle Curves adjustment can be applied to increase the contrast of the shot. Duplicate the base image layer and apply the adjustment to the copy. Application of unsharp masking may help to bring out detail but be careful not to overdo it. Again, work on a duplicate layer for safety.

From 1981 to 2011 the Space Shuttle programme was the public attention-grabbing face of NASA. In total, five different shuttles flew 135 missions

60 years of NASA

Libby Jackson looks back on six decades of American spaceflight and exploration

NASA turns 60 this month, making it just a little younger than the Space Age itself. On 9 July 1958, President Dwight D Eisenhower signed the National Aeronautics and Space Act, and the National Aeronautics and Space Administration was born. A few weeks later, on 1 October 1958, it formally opened for business, just shy of a year after the Soviet Sputnik satellite heralded the new era with its distinctive 'beep beep' radio signal.

The groundbreaking news of Sputnik 1's launch on 4 October 1957 had spurred the States into action. The US administration sought to bring together its multiple space programmes, most of them military, under a broader mandate. Initial thoughts of regulating space as a hostile battlefield gave way to a civilian, science-led focus as scientists and engineers argued its scientific possibilities. NACA (the National Advisory Committee for Aeronautics), which had been founded in 1915 and was responsible for aeronautical research, was expanded and reborn.

NASA's objectives included, "the expansion of human knowledge of phenomena in the atmosphere and space," and, "cooperation by the United States with other nations and groups of nations… and in the peaceful application of the results thereof." Six decades later, there can be no doubt that NASA has and continues to deliver on these aims.

A true reflection of the highlights and notable achievements of NASA could fill this issue many ▸

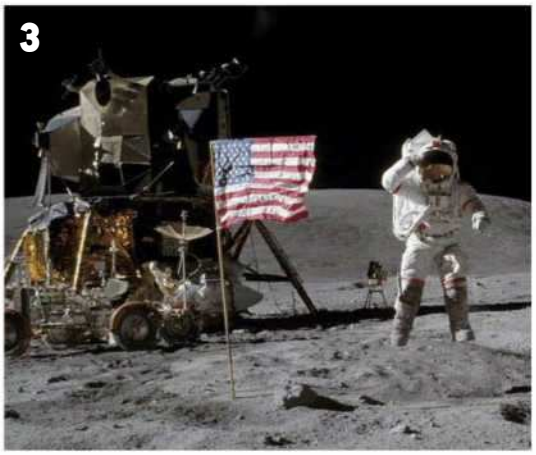
ABOUT THE WRITER
Libby Jackson is an expert in human spaceflight and author of *A Galaxy of Her Own: 50 Amazing Stories of Women in Space*

ISTOCK


1

▸ times over. From Pioneer 1 – its inaugural spacecraft launch after just 11 days of operations – which made the first measurements of the interplanetary magnetic field, through to recent successes such as New Horizons, which completed the exploration of the 'original' planets and showed us that Pluto has a nitrogen glacier heart, each mission has brought new scientific, technological and inspirational results and legacies.

The early days of the spacefaring era were dominated by the Space Race and human spaceflight. After Alan Shepard became the first American in space, John F Kennedy laid down the gauntlet to the Soviet Union with the challenge of reaching the Moon. That ambition drove much of NASA's course through the 1960s, pushing development in spaceflight at a rate never seen since. The Apollo landings are undoubtedly NASA's best-known achievements and the technical challenges, human bravery and incredible imagery left a legacy that will last long into the future. The scientific gains of the missions, physically captured in 382kg of Moon rocks that were returned to Earth, is still underpinning much of our understanding of planetary science. These rocks will continue to reveal new information, and some that were sealed in containers on the lunar surface have yet to be opened, waiting for new technology to come along to examine them.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4

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The outward urge

The 1970s saw NASA begin to explore the Solar System. Mariner 9 became the first spacecraft to orbit another planet – Mars – showing us that the Red Planet had an atmosphere, seasons and surface features that looked like dry river beds, intensifying the debate about possible life there. The Viking landers reached the surface to carry out experiments looking for life, but found no evidence.

Voyagers 1 and 2 changed our view of Earth and its cosmic environs with their grand tour of the Solar System. They sent back a wealth of information, showing us that all the outer planets

NASA X 15

A BRIEF HISTORY OF NASA

1 OCTOBER 1958
The National Aeronautical and Space Administration begins operations with a $100 million annual budget

11 OCTOBER 1958
Pioneer 1, NASA's first spacecraft, launches towards the Moon from Cape Canaveral

5 MAY 1961
Alan Shepard becomes the first American in space in the Mercury capsule Freedom 7

24 DECEMBER 1968
Lunar module pilot Bill Anders takes the iconic 'Earthrise' photo as Apollo 8 orbits the Moon

1. President Eisenhower (centre) with NASA's first administrator Dr T Keith Glennan (right) and deputy administrator Dr Hugh L Dryden. 2. NASA's first launch, Pioneer 1, was only 11 days after the space agency officially opened. 3. Apollo 16 commander John Young salutes the US flag. 4. Moon rocks collected on the Apollo missions have advanced our understanding of planetary science. 5. In 2011, Atlantis flew the final Space Shuttle mission. 6. The Challenger disaster in 1986 was a low point for NASA

have ring systems, while Voyager 2 remains the only spacecraft to have visited both Uranus and Neptune. Voyager 1's images of Earth and the Moon in a single frame and then later the mosaic of the Solar System, including the 'pale blue dot' of Earth, gave us new understanding of the scale of the Universe. Powered by their radioisotope thermoelectric generators, the Voyagers are both still alive and well, heading out into interstellar space over 15 billion km away, humanity's most distant scouts.

The 1980s heralded the launch of the Space Shuttle, a reusable vehicle that promised to revolutionise access to space with lower cost and regular launches, but budget constraints and design choices resulted in a vehicle that was inherently flawed. Twice in its history NASA has lost crews in space, the result of design decisions magnified by questionable management cultures and complacency. NASA had much soul searching and reinvention to undertake in the aftermaths of the Challenger and Columbia accidents, in 1986 and 2003 respectively, but on both occasions learned lessons and moved on. The memories of those crews, however, are enshrined in two engineering marvels that could not have made it into orbit without the Shuttle.

Hubble and the ISS

The Hubble Space Telescope produces incredible astro images that shed light on the depths of the Universe. NASA dodged a bullet with its unique astronaut-serviceable design, which allowed the installation of 'glasses' to correct the aberrations caused by the wrongly ground primary mirror. The Shuttle saved the day, and the servicing missions have given the telescope 28 years of operations and counting, contributing to the study of many astronomical questions from dark matter to the expansion of the Universe.

The other great Shuttle legacy is, of course, the International Space Station. It has been continuously inhabited since the start of the century, meaning that no child alive today has ▸

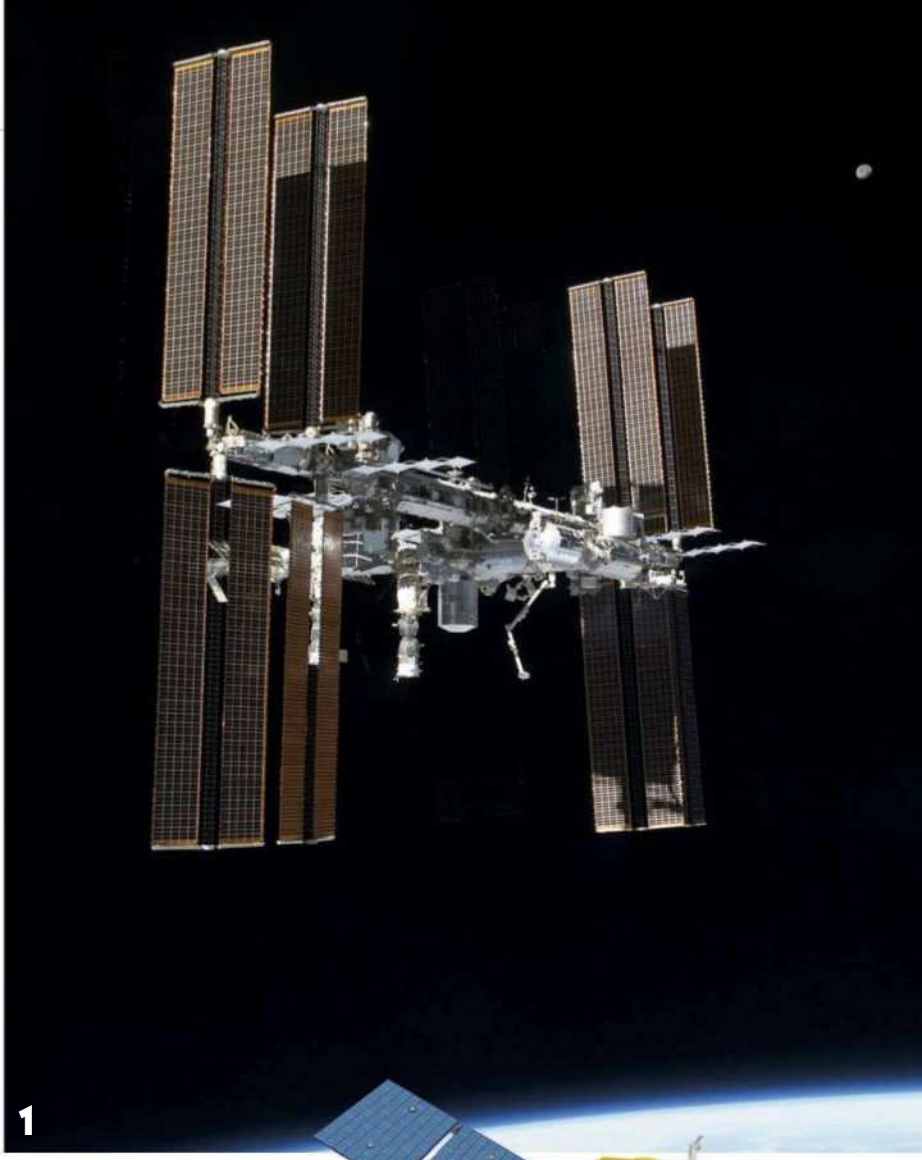
20 JULY 1969
Apollo 11 lands on the Moon. A day later Neil Armstrong is the first man to set foot on the Moon

14 NOVEMBER 1971
Mariner 9 enters Martian orbit, becoming the first spacecraft ever to orbit another planet

17 JULY 1975
US Apollo and Soviet Soyuz crews dock in space, signalling the end of the Space Race

12 APRIL 1981
The launch of Columbia marks the inaugural mission of NASA's Space Shuttle programme

6 DECEMBER 1993
Jeffrey Hoffman and Story Musgrave install corrective optics in the Hubble Space Telescope ▶



1. Continuously occupied since 2000, the International Space Station (ISS) has now orbited Earth over 112,000 times. 2. Launched in 2018, NASA's Transiting Exoplanet Survey Satellite (TESS) is hunting for exoplanets. 3. The vast mirror of the James Webb Space Telescope (JWST), which is due to launch in 2020. 4. The Kepler spacecraft, launched in 2009, is also searching for exoplanets

▸ lived in a time without humanity's presence in space. NASA has worked with its partners around the world to deliver this unique research laboratory and the crew that lives there work tirelessly to use the platform for education and inspiration, alongside the hundreds of science experiments that are carried out each year. The ISS is a testament to the international nature of space and the benefits that come from international cooperation.

The search for exoplanets

The pace of science and discovery is unrelenting and new technology continues to bring new knowledge. In the last decade NASA's Kepler mission has been searching our region of the Milky Way for planets around other stars that are similar to Earth. With over 2,000 exoplanets discovered to date, including the 2017 announcement of eight orbiting star Kepler-90, six of which are thought to be Earth-like, we are learning more about how unremarkable Earth might be in the Universe. And, with the launch in April 2018 of the Transiting Exoplanet Survey Satellite (TESS), NASA has ushered in a new era in the hunt for exoplanets.

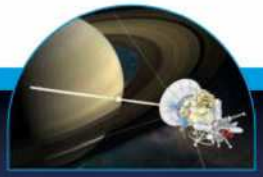
Woven amongst these NASA landmarks are many other missions that have also delivered unrivalled science and astounding imagery. Some, such as Galileo and Cassini, Spirit, Opportunity and Curiosity, are well known. Others, such as the sample return missions, Stardust and Genesis; the other great space observatories Compton, Chandra and Spitzer; or the Earth observation missions such as GRACE (Gravity Recovery And Climate Experiment) and the Jason series, attract fewer headlines but this is no reflection of the importance of their missions.

NASA's first 60 years have brought us triumphs, disasters, breakthrough science and breathtaking imagery, informing and inspiring people the world over. The missions that are being planned now, such as the James Webb Space Telescope, Mars sample return and the Lunar Orbital Platform-Gateway, will continue to expand human knowledge for many decades to come.

NASA X 8, SPACE X, NASA/CHRIS GUNN, NASA AMES/JPL-CALTECH/T PYLE, WORLD HISTORY ARCHIVE/ALAMY STOCK PHOTO, NASA/AMES RESEARCH CENTER/WENDY STENZEL, NASA/ESA AND G. BACON (STSCI), NASA/BILL INGALLS, NASA/JPL-CALTECH

2 NOVEMBER 2000
Expedition 1 arrives at the International Space Station, the start of continuous ISS occupation

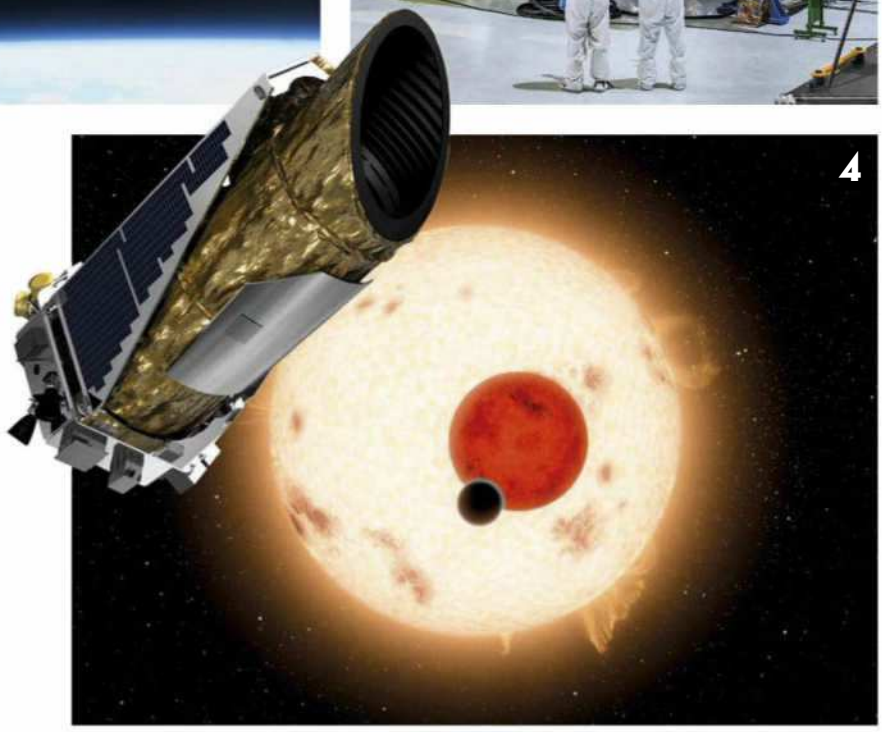
4 & 25 JANUARY 2003
Spirit and Opportunity land on Mars for a 90-day mission. Opportunity is still operational 15 years later



1 JULY 2004
Cassini enters Saturn's orbit, marking the beginning of 13 years of observations

7 MARCH 2009
The launch of the Kepler spacecraft, a mission to search for Earth-sized exoplanets

21 JULY 2011
With Atlantis landing at Kennedy Space Centre, the Space Shuttle programme closes



ASK A SPACE HISTORIAN

Steven J Dick, NASA Chief Historian and Director of the NASA History Office 2003-2009

When people think of space, NASA is often the first thing that comes to mind. Why is this?
Everyone knows about NASA first of all because of its human spaceflight efforts culminating in six landings on the Moon. The Space Shuttle was also a magnificent flying machine, but sadly what people remember most are the Challenger and Columbia accidents. Over the last 25 years people know about NASA primarily because the Hubble Space Telescope has produced such spectacular imagery. NASA is an inspiration to young people, as it was to me when I was a teenager.

What impact has the changing face of international cooperation had?
The Space Age began as a competitive 'Space Race' between the US and Russia during the Cold War. A little competition is good, but the budgets could not be sustained. International cooperation is much better, both for funding reasons and goodwill among nations. The gold standard over the last few decades has been the International Space Station, which involves five space agencies representing 17 countries.

Which NASA missions do you think should be better known?
Everyone knows about Hubble, but few know about its sister 'Great Observatories': the Compton Gamma Ray Observatory, the Chandra X-ray Observatory and the Spitzer Space Telescope. They operate in areas of the spectrum (respectively gamma ray, X-ray and infrared) that don't produce such spectacular images, but their work has been amazing. Also, the COBE (Cosmic Background Explorer) and WMAP (Wilkinson Microwave Anisotropy Probe) spacecraft have provided fundamental information about cosmology, including proof of the Big Bang.

What does the future have in store for NASA?
I think NASA has a bright future. There is certainly a place for commercial participation, even in far-fetched ideas like mining asteroids, if that is economically feasible. It's hard to see why the commercial sector would fund human or robotic exploration in and of itself unless it's profitable. This is where government funding will always be important, at least for governments interested in exploration and the future.

25 AUGUST 2012
Voyager 1 leaves the Sun's magnetic sphere (Voyager 2 is currently expected to join it in 2019)

5 DECEMBER 2014
First test flight of Orion, NASA's spacecraft that will take humans beyond low Earth orbit

14 JULY 2015
New Horizons makes its closest approach to Pluto. It is currently heading towards the Kuiper belt

4 JULY 2016
The Juno spacecraft arrives in orbit around Jupiter and starts sending back amazing images

22 FEBRUARY 2017
NASA reveals the Spitzer Space Telescope has found seven, Earth-sized planets around star TRAPPIST-1

Glamping with the stars

WHITEHILL COUNTRY PARK

Nestled within the rolling South Devon hills, yet close to the coast, the eco-friendly camping pods at Whitehill Country Park in Paignton offer the ideal spot for a countryside escape. This award-winning family run park boasts peaceful woodland trails, an outdoor pool, bar, restaurant, craft centre and soft play area. Whitehill Country Park, Stoke Road, South Devon TQ4 7PF

01803 782338 | www.whitehill-park.co.uk

TOP OF THE WOODS ECO CAMPSITE

We are located next to 325 acres of woodland and the Pembrokeshire National Park, with remote beauty, wild beaches, castles and wildlife all within easy reach. We offer a choice of eco-chic glamping and camping holidays, hosted weekend food nights and nature inspired on-site activities on our 27-acre Georgian farm in beautiful Pembrokeshire, Wales. Our guests enjoy a relaxed, back-to-nature glamping and camping holiday with campfires, storytelling, wildflower meadows and big open skies. There are wild beaches, ancient woodlands, bush craft, secret waterfalls, hidden gardens, hammocks, yoga, Kunekune pigs and free-roaming chickens to create a wonderful nature-inspired holiday, full of adventure and back-to-nature fun. Please contact us in advance if you are booking as a group. We can arrange private areas or adjoined pitches, but only with advanced notice. Top of the Woods Eco Campsite & Glamping Holidays gives you space & freedom to reconnect with nature, yourself & others.

01239 842208 | www.topofthewoods.co.uk

LOWER KEATS GLAMPING

Lower Keats Glamping is the ultimate destination for luxury glamping in Devon – perfect for groups, families, romantic getaways and it's dog friendly, too.

Our Glamping Meadow is the perfect place for little people to run among wildflowers, safely and freely. A true taste of "country life".

You can meet and feed the animals, collect eggs, or simply use us as base to explore the beautiful countryside and the Jurassic Coast nearby. Stunning views of our Devon meadowland and unadulterated night skies gives you the chance you deserve to get away from the hustle and bustle of everyday life, stress and worries.

Lower Keats Glamping delivers all you could want from a Devon break – all you need to do is sit back, relax and enjoy your stay.

07540 367386 | www.lowerkeatsglamping.co.uk

DIGLEA HOLIDAY PARK

Diglea Holiday Park is a spacious touring and camping field with a luxurious glamping facilities. Our Secret Garden comes with two brand new safari tents. On your arrival your bed will be made and on top a luxury Egyptian cotton towel bale for each person. These stunning Safari Tents are comfortable and luxurious with plenty of space for the whole family indoors and even come complete with an outside veranda!

The Safari Tents have a compact kitchen unit with sink, fridge, microwave, four ring hob, kitchen utensils, cutlery and crockery. The private bathroom in each is spacious, attractive and comes fully furnished with a free standing roll top bath. Electric sockets are practically positioned throughout and only ambient lighting for that African feel. If you do see a herd of elephants drinking at the watering hole you have probably had one too many bottles.

01485 541367 | www.digleacaravanpark.com

BALES ASH CAMPSITE

Dark and starry skies seemingly extend forever above this quirky North Devon campsite. While well equipped glamping at Bales Ash provides the perfect escape, the site itself has minimal lighting, the darkness broken only by the glow of fire pits dotted around the spacious fields. Friendly dogs always welcome. Prices from £60 a night for 2 people.

01769 561063 | www.balesash.co.uk

CUCKOO DOWN FARM GLAMPING

Five-star glamping and a million stars to be seen overhead in the East Devon dark skies area near Norman Lockyer observatory. Spot the Perseid showers in August from your wood-fired hot tub. TripAdvisor Certificate of Excellence 2018, family-run small peaceful site with four safari tents and two yurts.

01271 377432 | www.cuckoodownfarm.co.uk

LANGSTONE MANOR PARK

Langstone Manor Park sits on the edge of Dartmoor National Park in a sheltered valley outside Tavistock. Heated camping pods offer a great alternative to camping, without the tent. Five star toilets, showers and dishwashing areas are kept sparkly clean. The Kitchen @ Langstone on site serves evening meals every night and breakfast at weekends. Pet friendly.

01822 613 371 | www.langstonemanor.co.uk

HOE GRANGE HOLIDAYS

Hoe Grange Holidays in the Derbyshire Peak District is a perfect base for a stargazing short break. The two gorgeous glamping pods are designed in a chic contemporary style, with central heating, spacious en suite shower, kitchenette and comfortable fold out kingsize sofa bed – a cosy, peaceful space for two adults.

Enjoy the fantastic views from your pillow through the hobbit-inspired circular glass by day or set up your telescope to view the stars under the velvet dark skies by night. For an extra special magical experience why not hire the outdoor, log-fired Swedish hot tub? Book early as this is everyone's favorite place to view the stars!

A warm welcome awaits, with local goodies, including milk, eggs, bread and biscuits. All bed linen and towels provided, as well as free WIFI, a firepit, and outdoor seating.

Open all year round with a 2-night minimum stay, pets welcome by prior arrangement.

01629 540262 | www.hoegrangeholidays.co.uk

IN THE STIX

In the Stix is a glorious site set in the heart of un-spoilt Rutland, offering 4 geodesic domes with individual kitchens. We provide guests with the first mezzanine-level design in the UK, giving sleeping arrangements over two floors, and your own en suite bathroom with fully plumbed facilities and extra large shower. This, alongside the log burners, leather chesterfield sofas, and the comfiest beds, set us apart from glamping as you've previously known it.

All fully equipped, no need to worry about what you have forgotten, it's all here! Linens, towels and kitchen basics are all supplied, making the job of packing a simple one. In The Stix is the perfect spot for getting back to nature in our stunning, peaceful surroundings. Your evening of stargazing from your hot tub awaits. The rest of the world is a long way away from here... When will you visit?

IN THE STIX
RUTLAND GLAMPING

07958 378971 | www.inthestix.co

A sequence from the last solar eclipse in North America in 2017, an event which enthralled a nation and inspired a whole new generation of eclipse chasers

ABOUT THE WRITER
Will Gater is an astronomy writer, journalist and presenter. Follow him on Twitter at @willgater or visit willgater.com

Chasing the South American ECLIPSE

Will Gater looks ahead to one year from now, when the Moon's shadow will sweep across Chile and Argentina

ISTOCK

▲ Uninhabited Oeno in the Pitcairn Islands would be a great place to see the 2019 eclipse, except that no planes fly there and the ferry from Mangareva to the Pitcairns only leaves four times a year

The finale of a total solar eclipse can be a funny thing. In a single moment, at the end of the eclipse the world around you that was so dramatically transformed by the Moon's shadow returns to normal, as if nothing of import had happened in the skies above. That instant often prompts a swirling mix of emotions, from relief – if the eclipse chase has been successful – to overwhelming awe and even serenity. But observe enough of these unique celestial spectacles and there's one phrase you'll hear uttered again and again following their conclusion:

When's the next one?

Following last year's historic US eclipse it's a safe bet that many will have been bitten by the eclipse-chasing bug, whether they attended in person or simply saw the coverage. And if you, too, are one of those people wondering where and when it'll all happen again, the answer is South America, a year from now on 2 July.

The swathe of the planet from where the 2019 total solar eclipse can be seen lies mostly across the open ocean of the South Pacific, though it does cover the uninhabited Oeno Island, in the remote Pitcairn Islands. However, it's the thin strip of Chile and Argentina that the Moon's shadow crosses where most eclipse chasers will head to. The Moon's shadow will make landfall on the Chilean coast, close to the city of La Serena, before crossing the spectacular Andes Mountains and heading into Argentina, just skirting through southern Buenos Aires, before ending its journey across the globe 150km southeast of the city.

Heart of darkness

The eclipse path is defined by the dark core of the lunar shadow sweeping across our planet as the Moon passes between the Earth and the Sun. We say 'dark core' because the Moon's shadow is, in fact, composed of two parts: a lighter, outer region called the 'penumbra' and a darker, inner region known as the 'umbra'. To observe the breath-taking phenomenon of 'totality' – where the disc of the Sun is completely hidden by the silhouetted disc of

◄ The path of totality for the 2019 solar eclipse across South America

ISTOCK, PETE LAWRENCE, WILL GATER

Safety FIRST

Take precautions not to damage your eyes

When viewing or photographing the partial phases of a total solar eclipse it is essential to securely fit a certified solar filter – from a reputable manufacturer – onto any telescopes, camera lenses or other optical equipment you might be using. If you intend to watch the event with just your eyes you will still need to wear a pair of certified solar eclipse glasses to safely observe the partial phases of the eclipse; these glasses, again, should only be obtained from a reputable supplier or manufacturer. With both solar filters and eclipse glasses be sure to carefully follow the manufacturer's instructions for their use, otherwise you may risk serious eye damage.

▲ **Always use protection! If you ruin your eyesight, that's the end of your stargazing**

the Moon – you have to be located within the path of the 'umbral' shadow. This is the reason why the narrow ribbon of the Earth's surface along which the Moon's umbra will travel during a solar eclipse is commonly referred to as the 'path of totality'.

If you've never seen a total eclipse before you can expect a celestial show that is completely without parallel. If you want to see the 2019 South American eclipse for yourself, there are several companies in the UK and abroad offering guided tours. If you're considering travelling under your own steam, then as a rough guide flights to Santiago, Chile from London for late June and early July of this year start from around £950 at the time of writing. As Santiago is around 350km south of the path of totality, you'll need to arrange local accommodation and transport to a suitable viewing site within the eclipse path.

When you do finally make it to your viewing site in 2019 there are some important safety precautions that you'll need to take to prevent damaging your eyes. In order to view and photograph the partial phases of a total solar eclipse you will need to use a correctly-fitted, certified, solar filter on any optics you're using. If you intend to observe the event just by eye you will still need to wear a pair of certified eclipse glasses to view the partially eclipsed Sun.

▼ **The author's own spectacular shot of totality during the American eclipse of 2107, showing the Sun's corona**

First contact

Each total solar eclipse begins with a moment known as 'first contact'; the instant the Moon's disc first appears to 'touch' the disc of the Sun. In practice it can sometimes be difficult to see that the Moon has taken a 'bite' out of the Sun at this point – especially if poor daytime seeing is causing the Sun's limb to shimmer or ripple – so you may have to wait a minute or so from the official moment of first contact to see that the eclipse is underway.

First contact marks the beginning of the first 'partial' phase of a total solar eclipse when the Moon gradually covers more and more of the Sun, which becomes an ever-thinner crescent. It comes to an end with the start of totality, then a second partial phase begins when the Sun's disc starts to re-emerge. This is essentially the first partial phase in reverse with the Sun's crescent becoming wider until the instant when the Moon slips off the solar disc completely – what is known as 'fourth contact'.

During both of the partial phases, either side of totality, the changing appearance of the Sun's disc ▸

▲ Remember to bring refreshments and suitable clothing as well as protective glasses

Preparing for an ECLIPSE CHASE

Consider food, drink and clothing too

When chasing a total solar eclipse it's easy to focus on the big, important things – like the logistics of getting into the path of totality, or remembering to bring certified solar filters for your optics – that you can sometimes forget the little things that can help make observing and photographing these incredible events more enjoyable, and often more successful. Prime among these are the things that will ensure you're comfortable and safe on eclipse day. Do you have the right clothes for the climate? Do you have something to sit or kneel on and enough to drink and eat? And do you have things like sun cream and a sun hat if you're going to be in a hot, exposed location. Then there are more practical things to consider; for example, if your observing site is far from your accommodation will you have time to charge the batteries for any kit you'll be using? The bottom line is: preparation is key.

▸ isn't the only thing you'll want to monitor. Indeed, some of the most intriguing phenomena associated with total solar eclipses occur during these periods; oddly enough, one of the easiest to spot requires you to look not up at the sky but down to the ground.

That's because any tiny gaps in dense tree or bush foliage can often act as pinhole projectors, throwing little 'images' of the Sun's disc onto the ground. Where normally these small openings between the leaves create a dappled carpet of bright circles, during the partial phases of an eclipse these circles are transformed into a mass of small crescents.

A silvery twilight

As the first partial phase progresses and the Sun's crescent shrinks away, the light levels around you slowly begin to drop. Under clear skies this change can be very subtle at first, and you have to be vigilant to notice the decrease; it might, for example, manifest itself early on as a change in the colour of the sky, from a milky white to a slightly deeper blue. As totality approaches, though, the drop is unmistakable. At 10-15 minutes before totality the illumination of the landscape can be very strange – somewhat like a de-saturated, even silvery-blue, twilight, but with a subtly different quality.

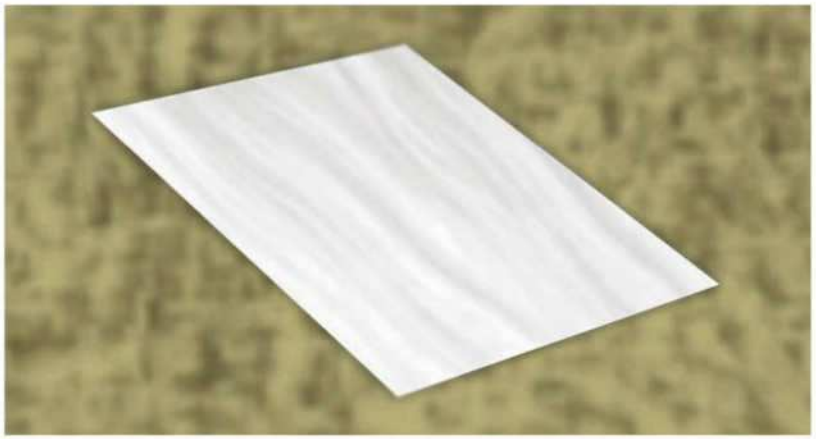
In the final minutes before totality keep an eye out on the ground for 'shadow bands'. This elusive eclipse phenomenon is poorly understood in terms of what causes it, but manifests as very faint, fast-moving wavy dark lines that race and shimmer across the ground. If you can, take an ironed, white pillowcase or large piece of white card with you to place on the ground, as this can make shadow bands much easier to spot.

While checking for shadow bands, look also for the darkening of the western horizon and, if your observing site gives you a vantage over a very wide area, the rapidly approaching umbral shadow. At this point observing the Sun using a certified solar filter will reveal a razor-thin crescent – a sure sign that totality is imminent.

Totality arrives when the Sun's disc is fully obscured by the Moon, and only during these moments when the Sun is completely hidden is it safe to remove your eclipse glasses. With totality the wispy 'streamers' of our star's outer atmosphere – the ethereal, glowing 'corona' – are suddenly revealed, stretching away from the obsidian-black disc of the Moon into the deepest-blue sky. This is also the time to look for any ruby-red prominences leaping off the limb of the totally eclipsed Sun – a truly extraordinary sight to behold, if you're fortunate enough for one to put in an appearance.

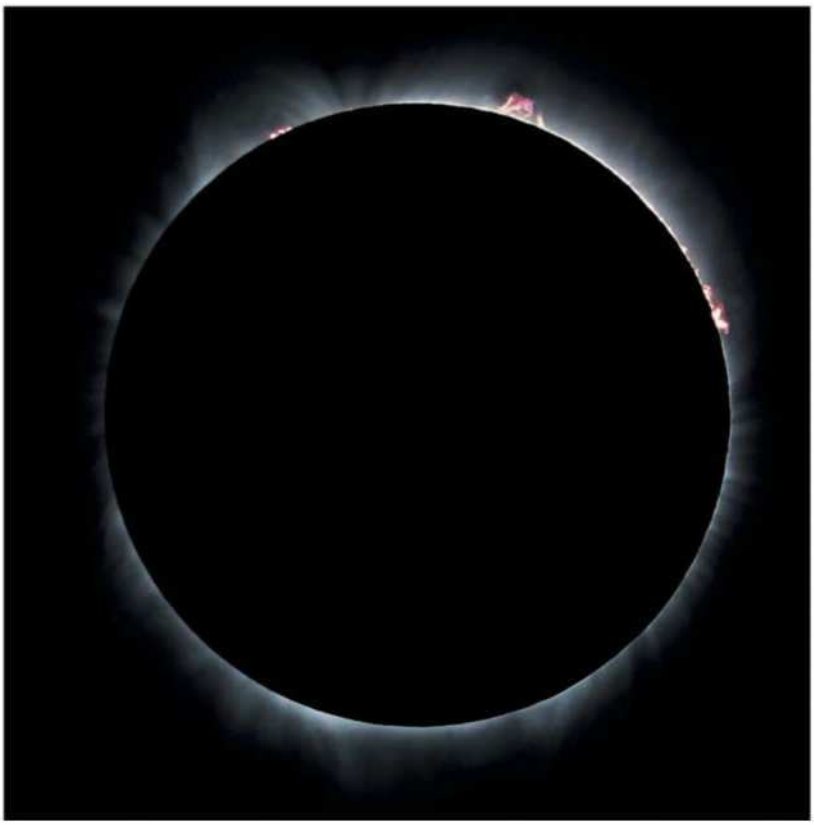
The length of totality

In 2019, the eclipse will last just over two-and-a-half minutes near the centre line on the western coast near La Serena, Chile. Further southeast along the



▼ You'll be able to see shadow bands much better if you have something large, white and flat handy

CHARLES WOLLERTZ/ALAMY STOCK PHOTO, WILL GATER, ISTOCK



▲ Totality enables you to see the Sun's corona, and if you're really lucky, you might witness some prominences too

path of totality, in Argentina, that figure drops to around two minutes. What will make this eclipse feel different from last year's in the US is that the totally eclipsed Sun will be lower in the sky – for example totality will begin at La Serena when the Sun is at an altitude of nearly 14° while at Venado Tuerto, in Argentina, it will only be around 4° above the horizon as the Sun is beginning to set.

This should enable some particularly striking astrophotography opportunities incorporating dramatic skylines and landscapes – especially in combination with the colours of the famous '360° sunset' that appears all around the horizon during the totality of a solar eclipse. However, you will have to be careful when choosing your observing location to ensure that the eclipse isn't hidden by large features in the surrounding landscape.

Ending on a low, then a high

Just prior to the end of totality be sure to reattach any solar filters you're using, so that you aren't caught out by the re-appearance of a thin sliver of the Sun's blazing disc. At the instant when the Sun does re-emerge, the second partial phase begins, and a little over an hour later the Moon will have moved off the solar disc completely, bringing the eclipse to an end. By this point the Sun will have already set for observing sites towards the eastern end of the eclipse track. While on the Chilean coast – in La Serena, for example – the Sun will be very low near the horizon for the moment of fourth contact.

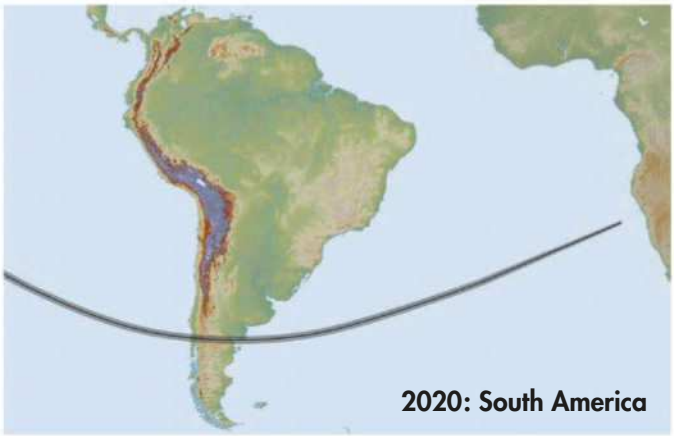
In the exhilarating minutes after the eclipse's conclusion you'll no doubt want to share stories and compare notes with your fellow eclipse chasers. But there's also much to be said for taking a moment to drink in the atmosphere and absorb what has unfolded. And whether it was your first or fifth total solar eclipse, among all that emotion and excitement maybe it'll be you who has that thought bubbling up inside them…

When's the next one?

When's the next one?

It's two in a row for South America and then one in Antarctica after that

After 2019's eclipse in South America, the next one will be in December 2020 in… South America again! This time, though, the path of totality will sweep across the continent further south, passing over the city of Villarrica in Chile as well as a large swathe of central Argentina; the maximum possible duration of totality during this eclipse will be just over two minutes. After that, the next total solar eclipse will be in Antarctica and the Southern Ocean in December of 2021, while some eclipse chasers are already looking even further ahead to the total eclipse that will be visible across parts of Mexico, the United States and Canada in April 2024.



SKILLS

Brush up on your astronomy prowess with our team of experts

WARNING
Do not look directly at the Sun with the naked eye or any unfiltered optical instruments

The Guide

The Sun up close

With **Pete Lawrence**

Revealed! The amazingly dynamic nature of our nearest star in H-alpha* and white light

*A hydrogen-alpha (H-alpha) filter makes the Sun's disc appear slightly larger than a white light one because it reveals the chromosphere, which sits on top of the photosphere. Only the photosphere is visible through a white light filter.

ACTIVE REGIONS

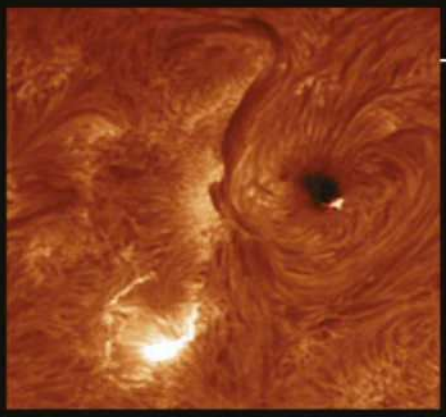
Sunspot groups, or active regions, take on a whole new appearance in H-alpha. Dark sunspots become harder to see, partially hidden under the surrounding chromospheric blanket. Around them, dark fibrils follow the intense magnetic fields associated with these regions. Large, bright areas called plage appear throughout and around sunspot groups.

SPICULES

The edge of the Sun's disc seems to have a thin skin running around it. This is a cross-section of the chromosphere. Under good seeing you can make out that it's made up of tiny jets known as spicules. Together, they make the edge of the Sun appear 'furry'.

PROMINENCES AND FILAMENTS

Giant clouds of magnetically influenced hydrogen plasma can often be seen hanging off the edge of the Sun through an H-alpha filter. Known as prominences, these can change appearance day-to-day or, in extreme circumstances, real time. When seen against the chromosphere away from the limb, they appear dark and are known as filaments.



DYNAMIC BRIGHTENING

Active regions may also show dynamic bright regions. Tiny star-like points of light called Ellerman Bombs may come and go, each releasing the same energy as several million atomic bombs. Larger ribbons of light called flares are associated with magnetic reconnection events, which may throw out huge clouds of charged particles known as coronal mass ejections.

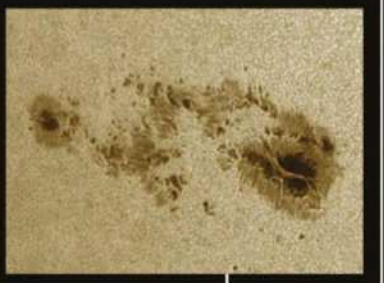
HYDROGEN-ALPHA*

DARK MOTTLING

An H-alpha filter shows the Sun's inner layer of atmosphere, known as the chromosphere, which sits on top of the photosphere. This is covered in a coarse, magnetically influenced light and dark pattern collectively known as dark mottling. The pattern is visible across the entire disc and makes the Sun resemble a giant orange.

ALL PICTURES: PETE LAWRENCE

WHITE LIGHT



SUNSPOTS

Sunspots appear dark against the photosphere, often occurring in groups known as active regions. A typical sunspot shows a dark inner core called the umbra, and a lighter surrounding region called the penumbra. Sunspots appear dark because they are cooler than the surrounding photosphere.

FACULAE

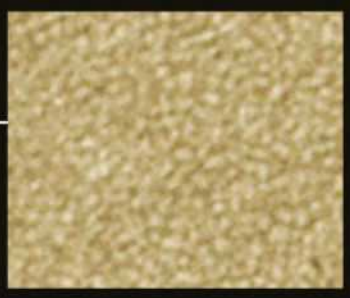
The limb-darkened edge of the Sun's disc provides excellent contrast for viewing faculae. These are magnetically affected regions where the Sun's 'surface' becomes more transparent, allowing you to see into the deeper, hotter areas below.

LIMB DARKENING

When the Sun's disc is viewed through a white light filter, the centre appears brighter than the edge. This is called limb darkening, and occurs because at the centre of the disc you can see deeper into hotter, brighter layers.

GRANULATION

The Sun's visible surface, or photosphere, is covered in a fine pattern called solar granulation. This can be tricky to see and image as it's easily hidden by poor seeing. Granulation represents the tops of huge rising convective cells reaching the photosphere.



WAYS TO OBSERVE

From DIY to precision engineering, you can view the Sun in safety

PROJECTION

Solar projection is suitable for small refractors. The idea is to point the scope at the Sun and place a screen, typically a piece of white card, behind the telescope's eyepiece. This method can show solar granulation, dark sunspots and bright faculae.

WHITE LIGHT SOLAR FILTER

An inexpensive sheet of white light solar safety material can easily be fashioned into a filter for use with any type or size of amateur telescope. It's available in A4 sheets, and allows you to view and image granulation, sunspot groups and faculae.

PERSONAL SOLAR TELESCOPE

An entry level H-alpha scope such as the Coronado PST will set you back around £800. This instrument is able to show prominences, dark mottles, filaments and many of the bright phenomena associated with active regions, such as plage and flares.

H-ALPHA SCOPES AND FILTERS

If you want to see even finer detail then there are larger aperture, narrower bandwidth H-alpha scopes available, typically for several thousand to tens of thousands of pounds. Solar H-alpha filter kits in a similar price range can also be used to convert night-time telescopes.

How to...

With **Mark Parrish**

Build a 1.25-inch filter wheel

Instructions for a home-built accessory to hold up to five filters

The filter loaded up for use with a telescope and a camera

Visual observers and imagers often make use of filters to enhance their view of an object or to capture specific wavelengths of light. A common set of filters is LRGB (Luminosity, Red, Green and Blue), which is used to bring out features in visual observing and, when used in conjunction with a monochrome camera and software, to capture full-colour, high resolution images. Other filters deal with only specific wavelengths such as H-alpha and Calcium-K, which pick up emissions in deep-sky and solar imaging.

Filters usually come with threaded sections on their outer ring, which are designed to screw onto the tube of your eyepiece or camera, but if you want to change filters during a session (essential for most imagers and desirable for visual observers), this is a very impractical method. To solve this problem, our 'How To…' project this month is a filter wheel that can hold up to five 1.25-inch filters. The filters are held in an internal carousel or wheel, which can be turned by hand to apply a chosen filter to the eyepiece or camera without disturbing your setup.

Our design features a low-friction bearing so that the telescope's not disturbed when the wheel's turned. There are small notches on the wheel so that as each filter engages, there's a slight click when the wheel's locked in position. There's also a red LED warning light that glows when the wheel is being turned but switches off when the filter is in place. This is a useful feature, as you are always confident that a filter is fully engaged before taking an image. We've also incorporated a small window through which you can view a label referring to the current filter. You can write your own labels, so you won't need to remember any numbers or count 'clicks' out in the field!

Spin the wheel

We chose thin plywood as the main material for our design as it's light and stable and, importantly for the home constructor, easier to cut out than steel or aluminium. The wheel is made from 6mm ply, which makes it thick enough for most common filters. The outer casing is made from 3mm ply and the inner walls are made from a glued-together sandwich of 3mm and 6mm ply, giving a 9mm

ALL PICTURES: MARK PARRISH

TOOLS AND MATERIALS

Tools
A hacksaw; a coping saw (or scroll saw/bandsaw); drill; Forstner bits (approximately 35mm for the eyepiece tube, 30mm for filters); smaller-sized bits for the bearing and battery clip; 2mm, 2.5mm, 4mm, 8mm, 9mm and 13mm bits for other holes; sander; small pliers; soldering kit; small, round file.

Materials
Small sheets of good-quality plywood – 3mm thickness about A3 size and 6mm thickness about A4 size.

Sundries
A 1.25-inch eyepiece extension tube (carefully sawn in two); four M4x25 screws and one M6x20 screw with suitable nuts and washers; five M3x4 grub screws; a small bearing with 6mm inner diameter; 14.5mm roller PCB switch; 5mm red LED with bezel clip; 2032 coin cell and holder; short length of thin wire.

Finish
Some spray paints or wood varnish to provide a nice finish; some white self-adhesive labels.

▲ The filter wheel's thin design doesn't introduce too much length to your system

thickness in total. The 3mm layer has channels cut into it for the wires to run through. A couple of washers below the bearing will raise the wheel up so nothing rubs when it turns. On the plans we've indicated small M3 grub screws (self-tapping in 2.5mm holes) to hold each filter in the wheel but we found that our 30mm drill provided a perfect friction fit for our filters so we didn't need to tighten ours.

The most important parts of the design are the notch positions on the edge of the wheel. Because roller switches and coin cell holders vary in shape and size, we would advise you to draw round yours to ensure they fit well within the narrow space before cutting out, rather than sticking exactly to the plans. Once the wheel and bearing are ready you can line up the filter holes with the eyepiece hole and position the switch before marking on the optimum notch positions. Once everything is painted (we painted the internal parts matt black in case any stray light finds its way inside), check again before gluing the switch in position.

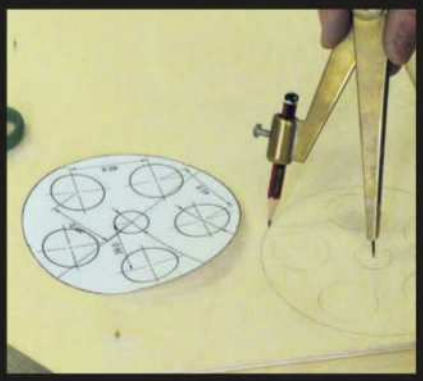
Because our filter wheel costs considerably less than a commercially made one you might consider making a couple, which will give you plenty of room for future filter purchases. Or if you already have a filter wheel with a few filters, make yourself one of these and use your savings to buy additional filters to put in it! If you use larger 2-inch filters you could adapt the design accordingly but be careful not to introduce unnecessary weight to your focuser.

Mark Parrish is a consummate craftsman. See more of his work at buttondesign.co.uk

YOUR BONUS CONTENT

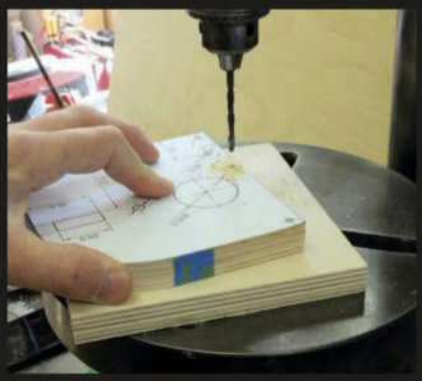
Download the plans, diagrams and additional photos for this project

STEP BY STEP



STEP 1

Print out the downloadable templates, cut them out and use them to carefully mark out the plywood sections before cutting out the basic shapes. It is a good idea to use a sharp point to mark through the centre of each hole to aid accurate drilling.



STEP 2

Tape the plywood casing parts together. Use a small 2mm drill to drill through all the layers – this ensures all the holes will line up later on. Separate the layers and enlarge the holes according to the plans. A pillar drill helps to ensure a vertical hole.

STEP 3

To make the wheel perfectly round here's a neat trick: before drilling the large wheel holes, make a 2mm central hole and pin the wheel to a wooden block. Smooth out any bumps by turning it against a sander, moving the block a little closer every turn.

STEP 4

Loosely assemble the wheel in the casing. Position the switch to determine where the notches will go. Make saw cuts then use a round file to make semi-circular notches to suit the switch. Drill 2.5mm holes from each notch to nearest filter for M3 grub screws.

STEP 5

After carefully sanding and painting the parts, fit the electronics. Glue the switch in place after checking it clicks on/off as the notches pass. Use a soldering iron to connect the components taking care to correctly orientate the LED.

STEP 6

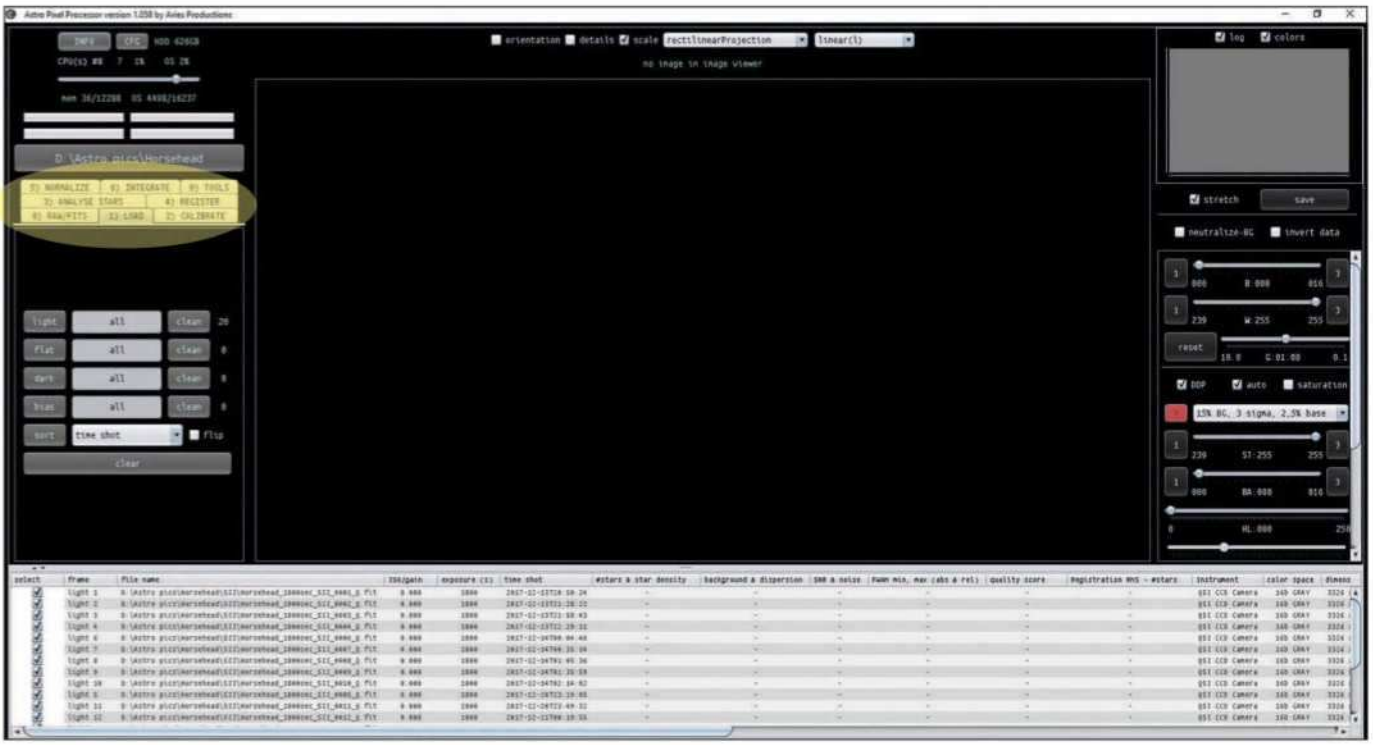
After checking everything works you can glue the two sections of the extension tube in place to form an eyepiece holder and nosepiece. Add the labels to the wheel so that they appear in the window then fit the filters. Then screw the unit together.

Image PROCESSING

With
Sara Wager

Integration with Astro Pixel Processor

It's time to combine all those disparate data files into an image ready for processing



▲ Ready to start integrating? Here's where you start with Astro Pixel Processor. The highlighted area shows the handily numbered main menus

Probably *the* most exciting part of astro imaging is integration; your hard-earned data is finally collated into an image you can process. Combined with the quality calibration frames we covered in issue 155, you will soon have the very best that your data can provide. With Astro Pixel Processor (APP), integration is a simple procedure that works fine with most default settings. But a few changes can make all the difference.

First you need to load in your light frames (and your flats, bias and darks if you are following the article on calibration frames in issue 155). Open APP, select a working directory then load your light frames by selecting the '1) LOAD' option from the left-hand menu and 'light' (plus 'bias', 'flats' and 'darks' if necessary) from the frame options below the menu.

> "APP will automatically pick a reference frame against which all your lights will be registered"

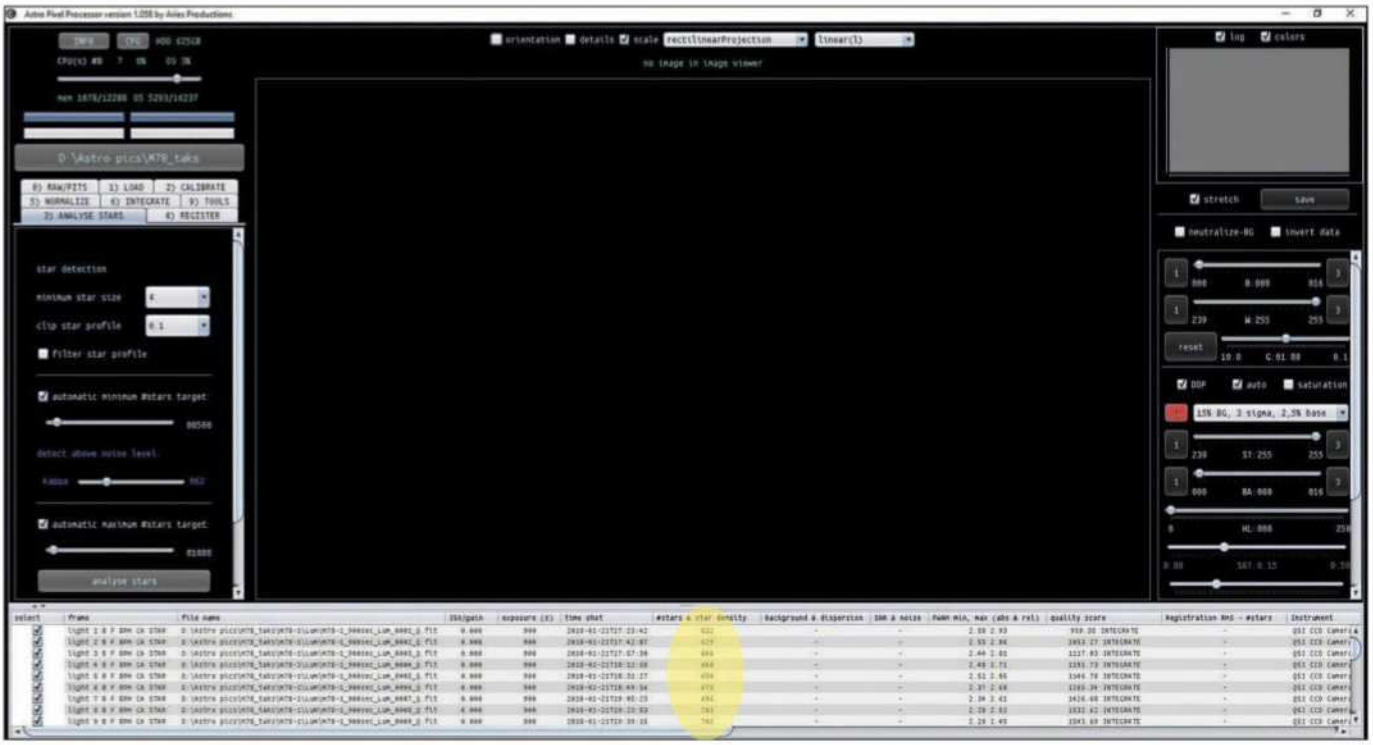
We are going to go through the menus individually here. You can change any default setting in the menus and they will remain the same until you exit APP. This allows you to experiment to find settings to give you the best results. The menus are numbered in a convenient order of use.

After you've made calibration frames you can then click on tab '3) ANALYSE STARS'. We're going to leave all of this at default, but if you're working at a long focal length you may find it beneficial to lower the 'DETECT ABOVE NOISE LEVEL' slider so that more stars are analysed.

Analysing your stars

Click 'ANALYSE STARS'. You can see the results of this step in the lower console. Here we have figures in the 600-700 bracket. On previous occasions, we've used

ALL PICTURES: SARA WAGER



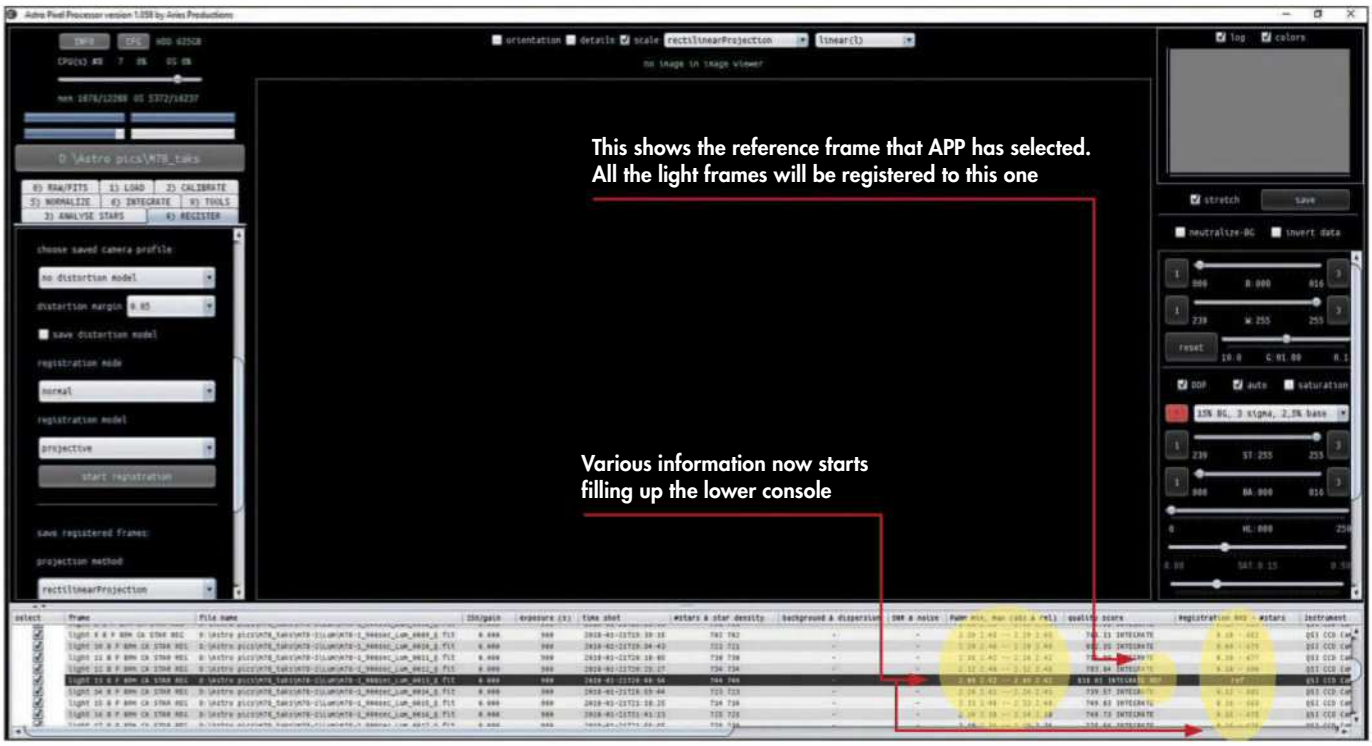
▲ After analysing your frames, APP's lower console fills with data. The values in the '#stars & star density' column need to be as high as possible

a long focal length scope with few stars in the frame taking this figure as low as 90. In cases like that, lower the 'Detect above noise level' slider to get the figure as high as possible.

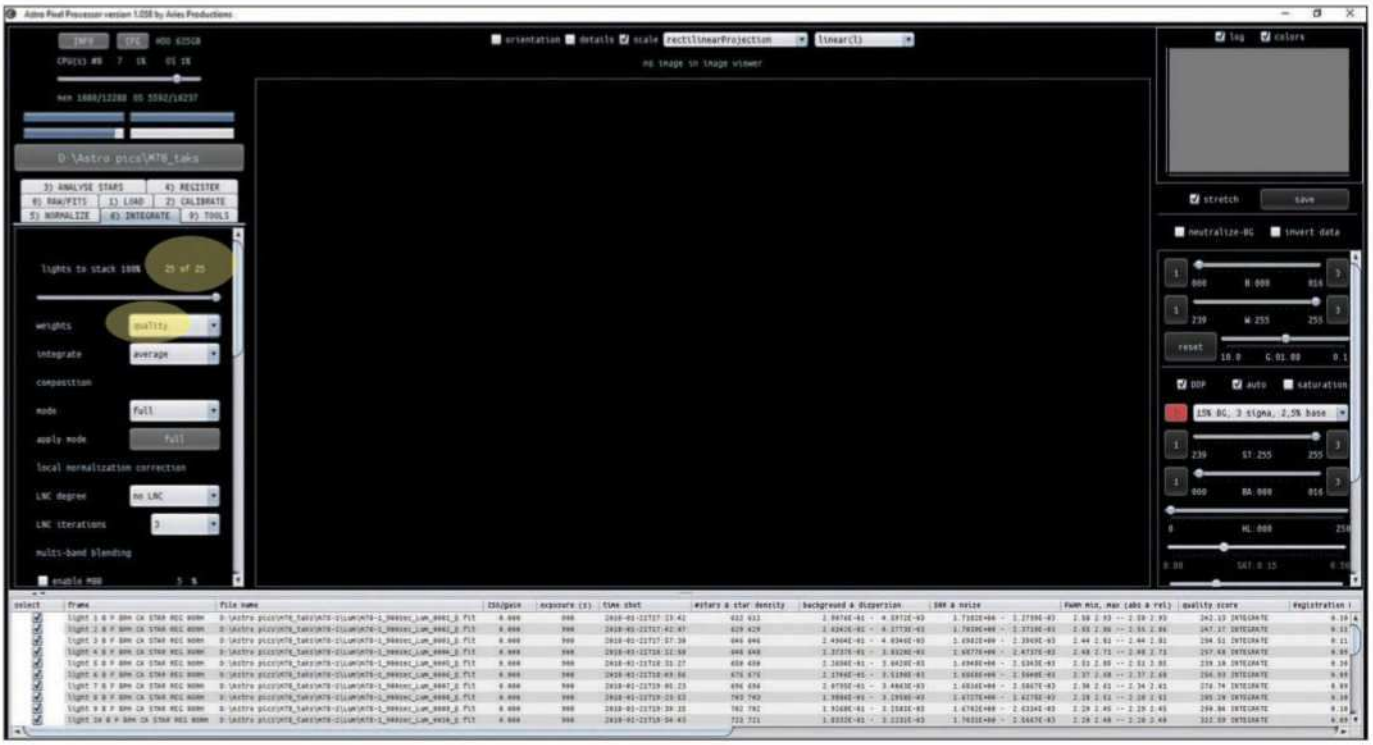
Click '4) REGISTER' and in this menu there's nothing to change unless you're making a mosaic (which is a whole other article). Click 'start registration'. APP will automatically pick a reference frame for all your lights to be registered against; this is shown in the lower console. You will also see now that there's more information added to each column in the console. The 'Registration RMS' figure shows you the quality of registration. In this case you want a low number and many of our frames have registered to within 0.1 of a pixel.

Click '5) NORMALIZE'. In this menu leave everything on the default setting for now. The 'regular' mode works well for frames that have all been taken with the same setup. The 'advanced' mode is used when for combining images from different equipment. Click 'Normalize Lights'.

Now click '6) INTEGRATION'. This is the menu tab where there are potentially ▸



▲ After you hit 'REGISTER' even more data appears, including the Registration RMS value, an indication of the quality of the registration



▲ When you 'INTEGRATE' APP tells how many of your lights are ready to stack, automatically rejecting any below par ones. Set 'weights' to 'quality'

"You can also view your rejection maps for an idea of what the rejection algorithm is doing"

▸ a lot of settings to change. So don't worry if you do your integration and think that there's something that could be done better; you can go back to the menu after the initial integration, change any settings you want and integrate again. Each time the integrated stack of data will be available to see in the lower console so you can compare different settings.

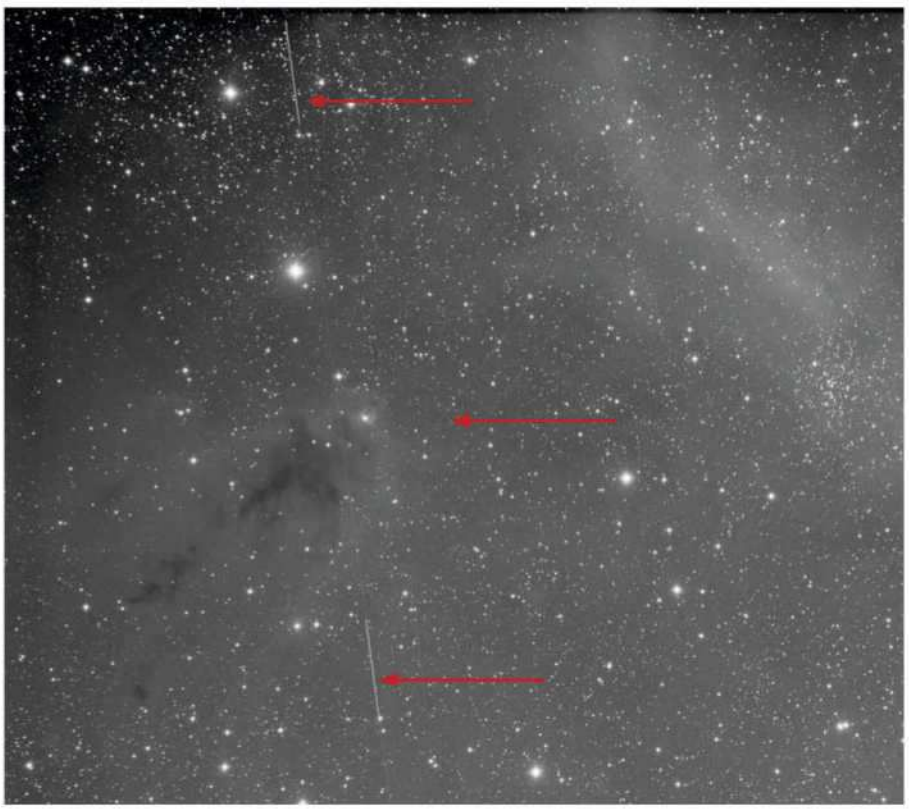
Integration

The first part of the 'INTEGRATION' menu shows you how many of your lights are ready to be integrated. If any of them have failed their star analysis or registration, for example, then they will automatically not show up here.

Select 'quality' in the weights menu. This stacks the data according to the quality score that's shown in the lower console. Keep composition mode as 'full' if you want to include the entire frame in your integration process.

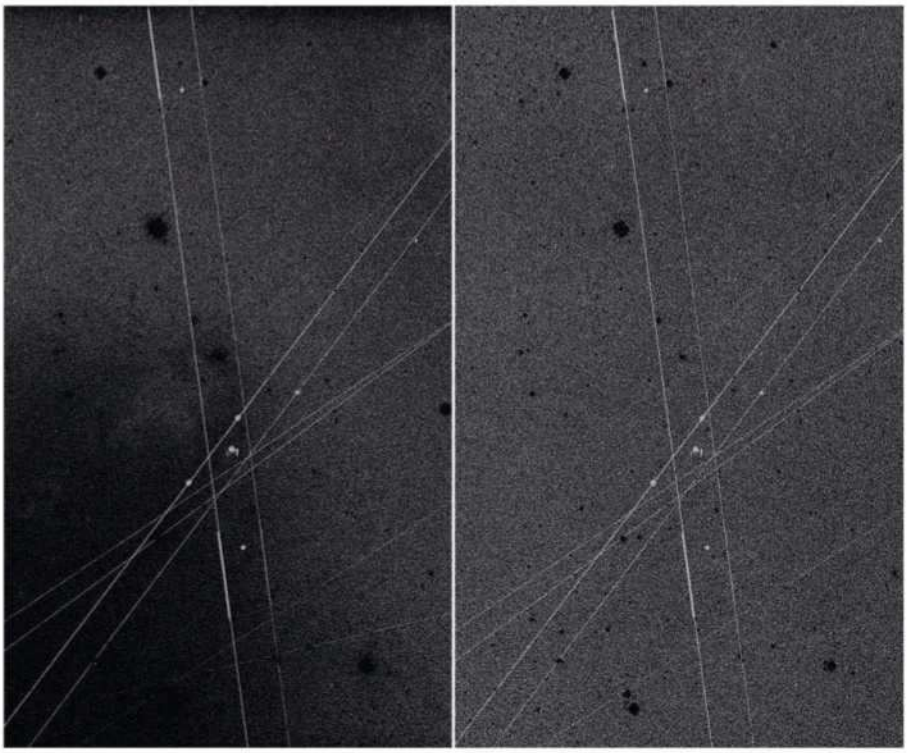
Further down the menu, you need to select an algorithm for rejecting pixels. This rejects: any hot or cold pixels that may be left; cosmic ray hits; satellite trails; and aeroplane lights. This is very important to get right, otherwise you are in danger of rejecting good data.

The two main rejection filters in APP are sigma clip and Winsor clip. Generally, if you are stacking more than 20-30 frames you should be using Winsor clip;



▲ This image reveals the trails that are left behind when no rejection is used

ALL PICTURES: SARA WAGER



▲ The uneven Winsor clip rejection map (left) and the improved results using LN and MAD filters

fewer than that, and sigma clip is the better choice. These filters have recently been further improved in APP with MAD (Median Absolute Deviation) and LN (Local Normalization). MAD works well with smaller data sets. LN works to correct illumination differences in data stacks. Taking all this into account, we've chosen to use 'LN MAD Winsor clip' for our sample image as we are stacking 25 light frames. We keep Kappa at '3' and Iterations at '1'.

Click 'integrate' and your stacked data appears in the lower console. You can also view your rejection maps for an idea of what the rejection algorithm is doing. The Kappa and Iterations settings will remove the outliers but will also remove some of the good data and signal so it is important not to be too aggressive in applying these filters. Once completed, you have your stacked image ready for additional processing if required.

SARA WAGER is an amateur astronomer who loves imaging nebulae in narrowband

▲ The final integrated stack; there's more work to be done to remove light pollution gradients and even out the background as well as processing

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Scope DOCTOR

With **Steve Richards**

Our equipment specialist cures your optical ailments and technical maladies

I like viewing double stars. I currently have a 6-inch reflector but would a refractor work best? What would you recommend for a budget of £300?

PETER GOLDSTEIN

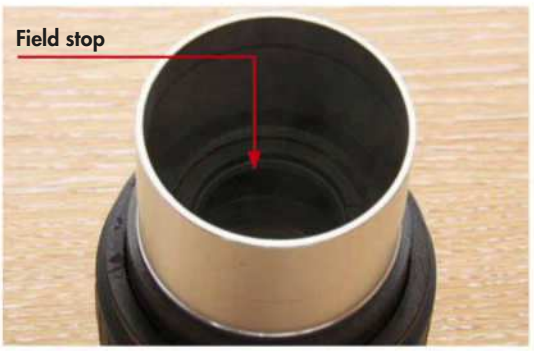
Observing double stars is a very popular aspect of astronomy and an area where amateurs can contribute greatly as very few professional observatories make such observations these days. Observational data is vital for increasing our understanding of stellar evolution, so amateurs can carry out real science as well as enjoying the wonderful sights.

A 6-inch reflector will produce some great views of double stars but a good refractor is likely to give a better observing experience as there is no spider vane to create diffraction spikes which can cause issues with very close doubles. A long focal length refractor will give excellent views and make focus easier to achieve but this needs to be combined with as large an aperture as you can afford. Larger apertures will reveal fainter companions but, just as importantly, they will have a higher resolution allowing you to split closer doubles. Long focal length refractors require a substantial mount to counter the effects of wind shear in particular.

Unfortunately, large aperture refractors can be quite costly, so a very popular, lower-cost alternative instrument for double star observing is the 5-inch Maksutov-Cassegrain. This instrument has a wide aperture and a long focal length of around 1,500mm in a short physical length and would be an excellent choice within your budget. The Sky-Watcher Skymax-127 Maksutov-Cassegrain or Orion Apex 5-inch Maksutov-Cassegrain telescopes would be excellent choices.

◂ The Sky-Watcher Skymax-127 Maksutov-Cassegrain is a good, low-cost choice if you want to see double

WWW.SECRETSTUDIO.NET, STEVE RICHARDS



▲ A field stop gives a crisp edge to the field of view

I have trouble seeing unclipped images through high magnification eyepieces. Is the position of the holder incorrect?

TINA COX

It is unlikely that the 'clipping' you're observing is caused by the positioning of the eyepiece in the eyepiece holder. However, eyepieces incorporate a field stop which consists of a metal or plastic ring that defines the edge of the field of view as part of their design. If correctly placed at the focal plane within the eyepiece, a field stop produces a well-defined circle which avoids a gradual drop-off in the fidelity of the view. The field stop limits the apparent field of view of the eyepiece which in turn limits the true field of view observed through the telescope.

If you know the diameter of the field stop, you can calculate the true field of view through the telescope in degrees by dividing the eyepiece field stop diameter by the focal length of the telescope and then multiplying the result by 57.3.

STEVE'S TOP TIP

How can I make my binoculars more stable for dark-sky viewing?

Binoculars are great instruments for observing the night sky but keeping them trained on an object of interest can be challenging. Although many come equipped with tripod bushes so that you can attach an adaptor and fix them on a standard tripod head, these are really designed for terrestrial use with the binoculars in a horizontal orientation rather than pointing up at the sky. There are special binocular mounts called parallelogram mounts that are better suited for seated observations but a simple and low-cost alternative is to simply lie back in a garden lounger with the binoculars resting on the perimeter of your eye sockets and your hands acting as stabilisers.

STEVE RICHARDS is a keen astro imager and an astronomy equipment expert

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BBC Sky at Night MAGAZINE

Reviews

Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each category is given a mark out of five stars according to how well it performs. The ratings are:

★★★★★ Outstanding
★★★★½ Very good
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor/Avoid

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Find out more about how we review equipment at **www.skyatnightmagazine.com/scoring-categories**

SEE INTERACTIVE 360° MODELS OF ALL OUR FIRST LIGHT REVIEWS AT WWW.SKYATNIGHTMAGAZINE.COM

90

Weighty matters – a Dobsonian reflector that's not as heavy as it looks

FIRST LIGHT

See an interactive 360° model of this scope at www.skyatnightmagazine.com/exdobgen2

Explore Scientific Ultra Light 16-inch Dobsonian Generation II

WORDS: MARTIN LEWIS

A sturdy 16-inch reflector that's surprisingly easy to transport and assemble

VITAL STATS

- **Price** £2,223
- **Optics** 16-inch (405mm) BK7 primary, 3-inch (72mm) secondary
- **Focal length** 1,825mm, f/4.5
- **Focuser** 2-inch rack-and-pinion with helical gearing and 10:1 reduction
- **Extras** Counterweights, fan battery box, red dot finder
- **Power supply for fans** 12V batteries or mains adaptor
- **Weight** 40kg
- **Supplier** Telescope House
- **Tel** 01342 837098
- **www.**telescopehouse.com

Dobsonian reflectors on their large, stable altaz mounts are very popular among visual observers who love their ease of use and quick set-up times. Combine this with a big aperture and you have the potential for a great, user-friendly visual instrument, capable of revealing many thousands of deep-sky objects and pulling out detail and contrast in objects barely visible in smaller scopes.

Explore Scientific produces a range of elegant lightweight truss tube Dobsonian reflectors with mirrors ranging in diameter from 10-inch, to a whopping 20-inch. We tested their Generation II 16-inch option, which has been upgraded recently to improve its mechanics.

The scope came extremely well packed in a huge 52kg box. Once we'd unbundled it, we started assembly but were soon scratching our heads. The problem was that the design of some of the altitude bearing components has been upgraded but the manual hasn't been updated accordingly. Some online picture checking was needed to work out how it all went together, particularly the attachment of the altitude bearings to the mirror box. With these attached, the rest of the assembly involved fixing the truss poles to the mirror box and then attaching the head to the pole tops. The former was easy but the latter less so; it's a tricky job requiring you to keep a good hold on the head, close to the heavier focuser, until all four truss tube pairs are securely connected with screw knobs.

Collimation made easy

A lot of thought has gone into the collimation method. Secondary adjustment is achieved via three spring-loaded knobs while the adjustment of the primary is accomplished by use of a specially supplied pole with a hex key at the end. This then engages with one of three socket screws around the front of the mirror. You can adjust both the secondary and primary whilst looking through the focuser, which is handy.

With the scope assembled and collimated we inserted a low-power, wide-field eyepiece and started exploring the skies. A thin crescent Moon was low in the west as dusk fell and we had a lovely crisp and detailed view of the lunar ▸

SKY SAYS...
Despite a few niggles this is a cleverly designed Dobsonian with a great method of collimation

ALL PICTURES: WWW.THESECRETSTUDIO.NET

Lightweight design

A 16-inch scope is a big piece of equipment and often back-wrenchingly heavy. The Explore design brings the weight right down while maintaining strength and rigidity. It does this by abandoning the particle board used by other manufacturers for the mirror box and the base, and instead uses aluminium for many of the telescope's main components and structure. The total weight of the scope is an impressively low 40kg.

The base box is made of aluminium panels riveted to an aluminium frame, making it a very light but sturdy unit. The mirror box uses similar build principles and even with the 14kg mirror inside it, it is not too difficult to lift the whole bearing box in and out of the base when you're setting up or breaking down the scope. You can do this by grabbing onto the tops of the attached aluminium altitude bearings, which double up as very convenient handles. The poles and the head are also aluminium, with steel only used for the secondary spider to give extra rigidity.

Focuser

The focuser is a handsome, smooth-action, solid aluminium unit with both coarse and fine (10:1) tuning controls and friction control. Taking the 1.25-inch adaptor out allows 2-inch eyepieces to be used. A locking screw underneath allows you to tension the focuser when using heavier eyepieces.

Truss poles

The well-made metal truss poles are in four hinged pairs, reducing the number of parts you have to transport and speeding up the process of fixing the mirror box to the head. Screws in the corner of the mirror box slide into slots in the truss hinges, which, when tightened, grip the poles in place. Four screwed knobs then attach the poles to the head.

Main mirror

The 16-inch (405mm) f/4.5 mirror is made of low-expansion glass, 43mm thick, and has a laser-engraved centre ring to help you collimate the scope before use. The mirror has a well-designed support system and two rollers at the bottom edge to support the mirror weight at low altitude.

FIRST LIGHT

Mirror cooling

The mirror box is an open design with plenty of space around it to help it cool down to air temperature. To speed things up, two 12V fans sit in the side of the mirror box, one wired to suck and the other to blow. A battery pack taking D cells is provided to power the fans.

SKY SAYS...
Now add these:

1. Explore Scientific 2/3-inch (17mm), 92° LER eyepiece

2. Explore Scientific 2-inch UHC Nebula filter

3. Explore Scientific 2-inch 2x Barlow/focal extender

▸ landscape. As the sky darkened we found the open clusters M36, M37 and M38, all three of which were sharp and high contrast. Although we were observing from a suburban site, the large aperture did its job collecting lots of photons and we started searching out some of the numerous galaxies in the spring sky. First, we found the Leo triplet, M65, M66 and NGC 3628, then some of the brighter ones in the Virgo cluster including the lovely, edge-on NGC 4762. M51 at the zenith with its companion was easy and at higher power gave hints of spiral structure. Later, the globulars M13 and M3 were well resolved and the session rounded off with a nice view of Jupiter low in the southeast sporting several darker belts.

Combatting stray light

The optics performed well once cooled down and the large, foam light baffle opposite the focuser helped keep the field dark and the contrast up. If you're troubled by nearby lighting, though, you might want to consider rigging up a lightweight shroud around the truss poles to help keep out stray illumination. It also helps reduce the likelihood of the optics dewing up in damp conditions.

There were a couple of niggles. The body of the red dot finder was so loose it kept going out of alignment and even at the lowest settings was much too bright. Although the scope movement was smooth and easy thanks to its low-friction PTFE-on-glass-board bearings, it was perhaps a little *too* low-friction when it came to altitude. This meant the balance had to be just right or the scope would rise or fall on its own depending on what altitude you were at. There are adjustable side blocks on the base to centralise the mirror box which are supposed to control the altitude friction, but we couldn't get the things to work. Instead the secret was to add or remove counterweights from the mirror box until it balanced at our desired altitude.

Although the Explore 16-inch is a big aperture scope, its design makes it relatively simple and lightweight to assemble and use. The few annoying niggles shouldn't stop you having many enjoyable hours scanning the night sky. S

Compact storage

For a 16-inch scope, it's more transportable than you might expect. The scope packs away very nicely when the poles are removed: the head sits on the lid of the closed mirror box to form a compact unit 55x55cm and only 75cm high.

Verdict

Assembly	★★★☆☆
Build and design	★★★☆☆
Ease of use	★★★☆☆
Features	★★★★☆
Optics	★★★★☆
OVERALL	★★★½☆

WWW.THESECRETSTUDIO.NET, MARTIN LEWIS

Wish Upon a Star in Sark

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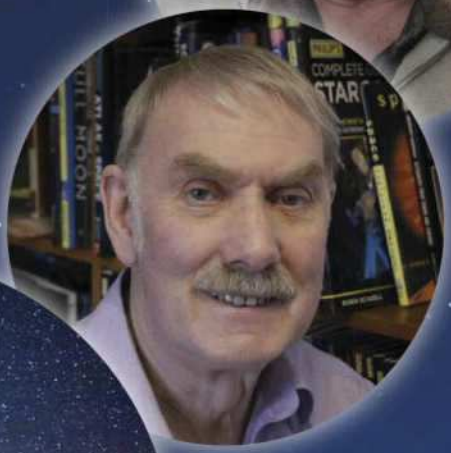

"Each year, the Perseids shooting stars create a free spectacle in the night sky. Their numbers peak on the night of 12 August this year, when hundreds should be visible during the course of the night. This year's event coincides with New Moon, so the sky will be dark, and astronomers are hoping for a great view. The meteors start to appear as soon as it gets dark, at about 10.30 pm, and numbers build up during the night, so it's worth staying up for as long as you can.

We'll have telescopes available for public viewing and we'll be giving popular evening talks on a wide variety of astronomical topics, from the Moon to the outer galaxies, over the weekend and on a few days either side."

ROBIN SCAGELL

PHOTOGRAPH COURTESY OF SUE DALY / SARK TOURISM

"Against a darkness so dense it seemed to have weight, shooting stars crossed the night sky of Sark. I counted four in 30 minutes."

NORMAN MILLER
BBC Travel

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FIRST LIGHT

See an interactive 360° model of this scope at www.skyatnightmagazine.com/evostar72ed

Sky-Watcher Evostar 72ED DS-Pro refractor telescope

WORDS: PAUL MONEY

Looking for a multitasking scope that's as good for viewing as for imaging?

VITAL STATS

- **Price** £299
- **Aperture** 72mm
- **Focal length** 420mm, f/5.8
- **Optical design** ED doublet lens with multicoated surfaces
- **Mounting** Tube rings & 45mm dovetail bar (with 1/4-20 tripod threads)
- **Focuser** Dual-speed 2-inch Crayford Focuser, 11:1 ratio
- **Weight** 1,955g
- **Extras** Removable dew shield, standard finderscope shoe, aluminium carry case
- **Supplier** Optical Vision Ltd
- **Tel** 01359 244200
- **www.**opticalvision.co.uk

Short-focus ED refractors are a highly popular and versatile class of telescope that can be happily used in a variety of roles from the purely visual through to wide-field imaging purposes. So let's take a look at Sky-Watcher's latest offering in this area – the Evostar 72ED DS-Pro.

What you get is a tube-only system with a finder shoe bracket, tube rings and a small Vixen-style mounting bar, along with a dual-speed Crayford anti-backlash focuser. Be aware, though, it doesn't come with an eyepiece, finderscope or star diagonal – great if you own them already as it keeps the cost of the 72ED down – but if you don't, it's something to factor in to your buying decision.

In the past Sky-Watcher, like most manufacturers, went into detail about the glass being used for their scopes' objective lenses, but the company seems to have changed its policy. For this model we only learn that the doublet objective lens has one Extra-Low Dispersion (ED) glass element and that Schott glass is used for the crown element. That aside, the lens *has* been treated with Sky-Watcher's Metallic High-Transmission Coatings, which, according to the company's blurb, gives a 99.5 per cent transmission of the light.

We approached the review in two stages, with a visual performance test and tour first, after which we did some deep-sky imaging using both a Canon EOS 50D DSLR and a GPCAM2 290C camera.

Performance test and tour

To help with the visual test Sky-Watcher also loaned us a dielectric diagonal and a 9x50 right-angle finder, which are optional extras. We used our own eyepieces which included 26mm, 10mm and 6.4mm 1.25-inch fit along with our Sky-Watcher 28mm and Ethos 21mm 2-inch eyepieces. One thing to note: the standard 9mm Sky-Watcher 1.25-inch fit eyepiece often supplied with many of the company's scopes would not come to focus but we had plenty of other options and all our other eyepieces focused fine.

With our reliable 26mm eyepiece we found Regulus pin sharp across three quarters of the view with some distortion towards the edges. Overall the view was good with pleasing colour correction. It ▸

Take it anywhere!

Small apo class refractors such as the original Equinox 80ED used to be quite heavy for their size but the latest small scopes from Sky-Watcher and other manufacturers have brought the weight down considerably and the 72ED DS-Pro is no exception. The optical tube weighs less than your average Chihuahua, just 1,955g. Plus, it's only 42cm long, so it's a very short tube system, and the dew shield is removable, all of which adds up to a great get-up-and-go-anywhere telescope, perfect for taking on holiday for viewing and imaging under far-flung dark skies. The 72ED DS-Pro is also an ideal companion to Sky-Watcher's Star Adventurer travel mount that we've reviewed in the past (see issue 113 and issue 143 for the mini version). Indeed, we used it to take images with our Star Adventurer, and found the whole system quick and easy to set up, a great incentive to invest in the telescope.

SKY SAYS...
A satisfying, lightweight ED refractor, but be aware of what it isn't supplied with

ALL PICTURES: WWW.THESECRETSTUDIO.NET

Optics

The front lens element consists of a doublet objective lens with extra-low dispersion (ED) glass and a crown element composed of Schott glass. The objective lens has Sky-Watcher's Metallic High-Transmission Coatings on all optical surfaces for good control of colour correction, giving a greenish hue to the front surfaces.

Dew shield

The dew shield is of the fixed variety but can be taken off for lens cleaning. The inner surface is coated matt black which reduces internal reflections, and during our testing period the optics weren't dewing up even after a couple of hours of use.

Tube rings and vixen bar

The tube is attached to a mount via two tube rings and a short Vixen-style, dovetail bar. The bar can attach to a standard telescope mount via a Vixen saddle or, for lightweight tracking mounts, the bar has two 1/4-20 tripod threads giving flexibility for mounting.

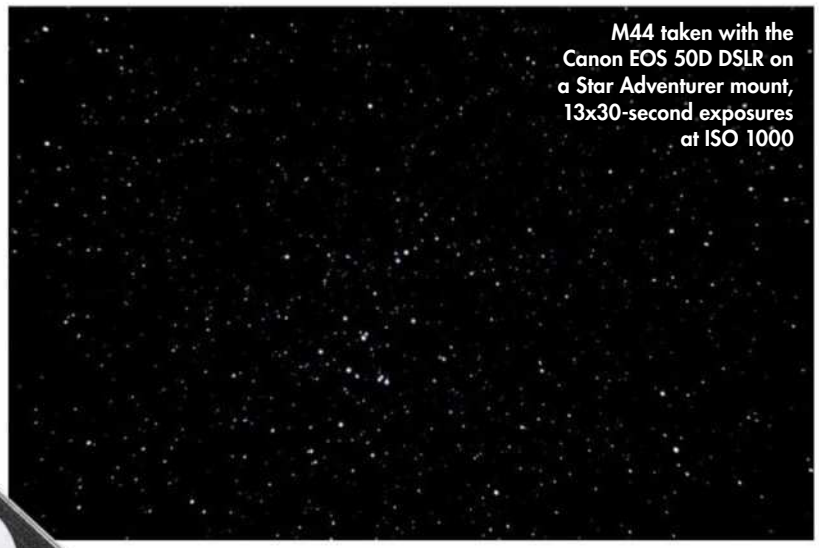
Focuser

The focuser has 38mm of focus travel and is a dual-speed, 11:1 ratio, 2-inch, fine-focusing rack and pinion design with tension adjustment underneath. The latter allows for heavy equipment such as large cameras to be attached and locked, so the focus doesn't slip during imaging.

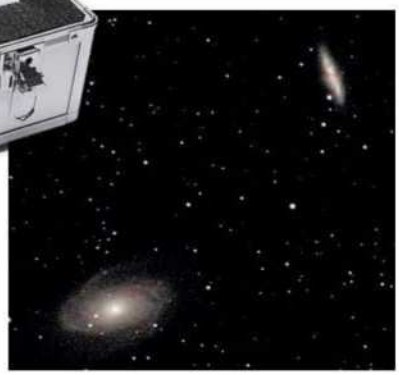
FIRST LIGHT

Carry case

Consistent with many Sky-Watcher small telescopes this one comes with a smart, sturdy, aluminium hard case to protect the 72ED DS-Pro. Inside is plenty of room and cut-outs for other equipment such as diagonals and eyepieces. It can be locked for secure storage.



M44 taken with the Canon EOS 50D DSLR on a Star Adventurer mount, 13x30-second exposures at ISO 1000



▲ M81 and M82 captured with a Canon EOS 50D DSLR on an AZ-EQ6 mount, 12x120-second exposures at ISO 1000

▲ M82 captured with a AZ-EQ6 mount and a GPCAM2 290C camera, using a stack of 90x40-second exposures

▸ gave a wide-field view of the Beehive Cluster, M44, in Cancer which sparkled with stars. For many deep-sky targets the view was quite wide so even the widely spaced galaxy pair of M81 and M82 seemed small. However, swapping to our 10mm eyepiece we enjoyed the subtle glow of the oval disc of M81 and could discern the irregular, mottled disc of M82.

It's always fun to seek out double stars so we turned to Algieba in Leo then Castor. They just split with the 10mm but by swapping to a hardly used and almost-forgotten 6.4mm eyepiece they split very cleanly to give a great view. Noting that Arcturus was well above the horizon, we sought out the globular cluster M3, and were rewarded with very satisfying views using the 10mm and 6.4mm eyepieces, while the Eskimo Nebula, NGC 2392, over in Gemini was a lovely, if small sight, in the 10mm.

Attaching the camera

We found we had to use a spare extender when we tried to attach our DSLR, otherwise we couldn't achieve focus. The focuser has 38mm of travel with a 12mm thickness adaptor at the end while our own adaptor added another 47mm giving us more leeway for focusing. We took a selection of images using our Star Adventurer tracking mount, imaging M44 with 13x30-second exposures for a satisfying image. On another night, using our AZ-EQ6 mount, we imaged M81 and 82, using 12x120-second exposures showing how wide the view was.

We also used our GPCAM 290C, which gave a closer view of M82 and took 90x40-second exposures showing pleasing detail. Then we caught a good view of the crescent Moon with both cameras to round off the test. Swapping back to our various eyepieces, we achieved some crisp views of the Moon and, later, Jupiter. The latter was quite small and needed high magnification, but we could see the bands and spot the four Galilean moons too.

It was a shame the summer nebulae were not available as we suspect the North America Nebula, NGC 7000, would be a great target for this scope. Overall, the Evostar 72ED DS-Pro was a satisfying, lightweight scope to use. S

Verdict

Build and design	★★★★½
Ease of use	★★★★★
Features	★★★★½
Imaging quality	★★★★½
Optics	★★★★½
OVERALL	★★★★½

SKY SAYS...
Now add these:

1. 2-inch dielectric diagonal
2. 9x50 right-angled finder
3. 0.85x focal reducer/ corrector

WWW.THESECRETSTUDIO.NET, PAUL MONEY X 2

FIRST **LIGHT**

See an interactive 360° model of this camera at **www.skyatnightmagazine.com/althypermono**

Altair Hypercam 183M V2 mono astronomy imaging camera

WORDS: TIM JARDINE

A deep-sky specialist that's especially impressive with narrowband objects

VITAL STATS

- **Price** £665
- **Sensor** Sony Exmor R IMX183 BSI
- **Sensor size** 5,440 x 3,648
- **Pixel size** 2.4 microns²
- **Bit depth** 8-bit and 12-bit modes
- **Camera size** 80mm x 65mm
- **Connection** USB 3.0 + ST4
- **Weight** 320g
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.**altairastro.com

Having previously reviewed the colour Altair Hypercam 183 (see issue 147), here we're reviewing its updated, monochrome brother. The compact Hypercam 183M is a great match for short focal length refractors or camera lenses. We chose our trusty 3-inch (75mm), f/6.7 telescope which would give a nice flat field across the camera sensor. To take colour pictures with a monochrome camera requires separate colour filters; standard 1.25-inch models easily cover the sensor. The camera itself does have a built-in filter which blocks infrared and ultraviolet wavelengths.

Set-up was simple: download and install the driver package and plug in the camera. We operated it with the AltairCapture software, but it's also compatible with the popular SharpCap. Once the camera's selected in the software, the built-in cooling fan turns on and a red LED lights up.

The mono Hypercam 183M is geared towards deep-sky imaging, although with user-defined Region of Interest (ROI) settings, taking lunar, solar or even planetary pictures is possible, as the camera will also record video files that can be processed and stacked into a final image. The smaller the ROI chosen, the faster the frame rate and smaller the eventual file size. However, given the low position of the major planets at the time of the test and the apparent reluctance of the Moon to put in an appearance, we opted to test the camera on a variety of much fainter, deep-sky targets.

SKY SAYS...
Opens the door to simpler deep-sky imaging and slashes the length of long exposures

Our first was the popular pairing of M81 and M82 – Bode's Galaxy and the Cigar Galaxy – as these two offered the camera a chance to show what it could do on faint swirling galaxy arms along with bright galactic cores and dust lanes. For these exposures we selected the 12-bit operating mode, rather than 8-bit, adjusted the gain setting to five, and took a series of exposures, each of five minutes.

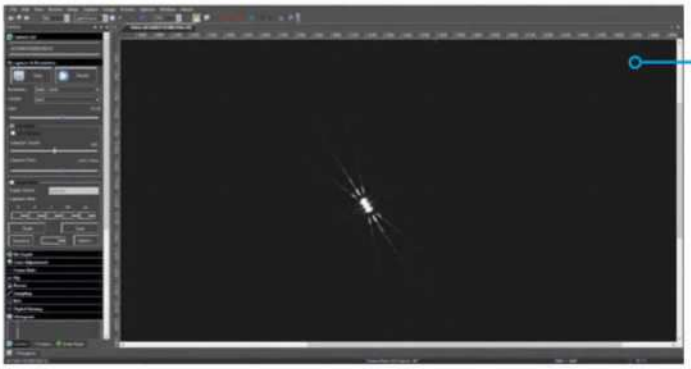
Trial and error

We found it took quite a bit of trial and error at first to settle on the most useful gain setting for each target, although after a few nights' practice it was getting easier. Generally speaking, lower gain settings resulted in smoother, cleaner images, but the increased sensitivity of higher gain offered an acceptable compromise on certain targets. The ▸

Sony Exmor R CMOS sensor

As camera technology advances, the benefits to astrophotography become ever more apparent. The Hypercam uses a Sony Exmor R CMOS sensor, designed using a technique known as 'backside illumination'. This clever electronics arrangement allows smaller pixels to be as sensitive as larger ones, meaning that many more of them can be assembled together without increasing overall sensor size. This offers a high resolution, 5,440x3,648 pixel array, in a sensor less than 16mm across the diagonal. In more basic terms, it allows for a compact, highly sensitive, cost-effective camera. A smaller camera chip means that more telescopes and camera lenses can be used, along with smaller accessories like filters, all of which combines to reduce the overall cost of an astrophotography setup. Fast, sensitive cameras like the Hypercam with IMX183 sensors also allow for shorter exposures than are traditionally used, which in turn means that less sophisticated telescope mounts and portable equipment can produce high quality images without star trailing or rotational effects.

WWW.THESECRETSTUDIO.NET X 4, TIM JARDINE



AltairCapture software

The image-capturing software allows you to take either video or pictures with ease. It is simple to select between 8-bit or 12-bit images, full frame or ROI capturing, gain setting, exposure lengths and so on. With live view mode and a high gain setting, focusing the telescope is a straightforward process.

Temperature sensor and fan

One of the updates in this version of the camera is the addition of a temperature sensor. This provides a real-time read-out of the temperature within the camera, useful for monitoring calibration exposures. Turning off the fan results in an immediate rise in temperature by a couple of degrees.

ST4 guide port

The rear of the camera houses an ST4 connection port, allowing the camera to be linked directly to a telescope mount via the supplied cable. In this configuration it then has the option to be used as an auto-guiding camera, and it is certainly sensitive enough for the task, if required.

Compact and lightweight

The compact Hypercam 183M is just 80mm in length and 65mm in diameter, weighing in at just 0.32kg, ideal for mounting on portable astronomy mounts. It is powered and operated via a single, 1.5m USB 3.0 cable, and is fully backward compatible with USB 2.0 hubs, extensions and laptops.

FIRST **LIGHT**

M42-thread or C-mount nosepieces

The Hypercam is supplied with a 2-inch nosepiece which screws into the M42x0.75mm thread on the front. In addition, there's a nifty little adaptor which can be fitted inside this thread, converting the connection to the popular C-mount style, compatible with 1.25-inch eyepiece holders.

SKY SAYS...
Now add these:

1. Altair 60 EDF doublet refractor

2. Starwave 50mm guider & GPCAM combo

3. iOptron SkyGuider Pro imaging mount

▸ resulting image showed impressive detail in both the faint outer arms of M81 and within the bright glowing core of M82.

Moving onto globular clusters, we were pleased that the camera achieved sharp captures of the bright cores of clusters like M13 in Hercules, without losing the much fainter outer stars. For this we used the lowest gain setting. A test on M3 in the same area revealed that a higher gain and shorter exposures wasn't the best option for globular clusters, as some of the central stars blurred into each other.

We were particularly interested to see how the camera performed on objects requiring special narrowband filters and – normally – exposures of over 20 minutes. The best available target for this proved to be the Crescent Nebula, NGC 6888, and we went after it with our 7nm H-alpha filter. This type of target can be more suited to higher gain settings, so we nudged gain up to 20 and captured some seven-minute exposures. The results did produce some unwanted artefacts, notably a bright glow on the middle edge of the image, so taking calibration frames is a must. The resulting stacked image demonstrated good sensitivity to faint emission nebulosity, and the calibration frames helped negate the unwanted artefacts.

Attractively priced and easy to use, this mono Hypercam opens the door to deep-sky imaging, including spectacular narrowband objects. S

Verdict

Build and design	★★★★½
Connectivity	★★★★★
Ease of use	★★★★½
Features	★★★★½
Imaging quality	★★★½☆
OVERALL	★★★★½

◂ An RGB composite of M81 and M82, created using 100 minutes of luminance exposures plus 5x5-minute each of RGB

▾ An RGB composite of Messier 13, using 15x5-minute luminance exposures plus 3x5-minutes each of RGB

▴ A monochrome image of NGC 6888 without using calibration files, showing the effects of camera amp-glow

▴ And here's a version using calibration frames; 33x7-minute exposures through a Baader H-alpha filter

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Books

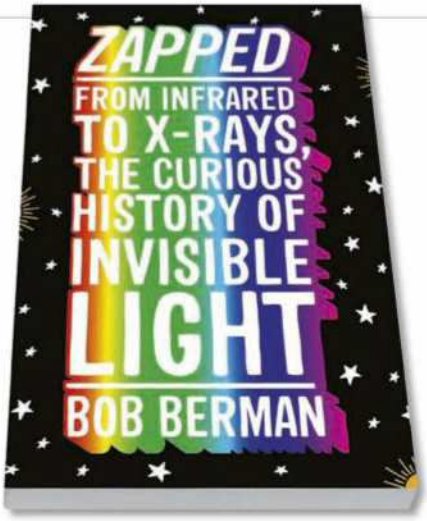
New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

Zapped
From Infrared to X-rays, the Curious History of Invisible Light

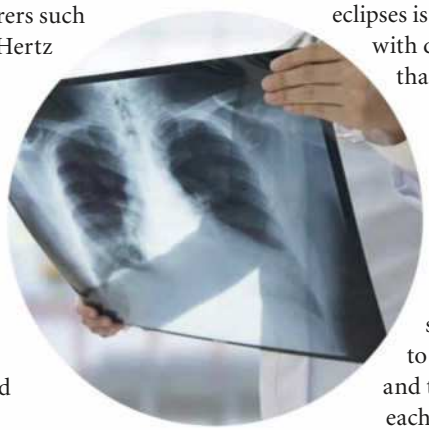
Bob Berman
Oneworld Publications
£9.99 ● PB



For every subatomic particle in the Universe, there are one billion photons of light. They make up 99.9999999 per cent of everything in the cosmos, yet light, both visible and invisible, is an area of science that we mostly take for granted. *Zapped* examines the full electromagnetic spectrum from radio to gamma rays and the book sparkles with facts and figures.

Zapped is fast-paced and leads us briskly through each wavelength, from early discoveries and discoverers such as Herschel, Ritter and Hertz through to the latest developments. The history and science are explained clearly and concisely, while the writing style is chatty and humorous.

Scientific studies and research are scrutinised, popular myths are debunked and unfounded fears are allayed – no, microwaves from mobile phones won't fry your brain. The benefits and dangers of exposure to UV rays from the Sun are examined. Hidden threats are also discussed. For example, a whole-body CT scan can expose you to more radiation than would have been experienced by a Hiroshima survivor standing a mile from the blast. The cautionary tale of the early uses and misuses of X-rays I found particularly interesting. X-rays were claimed to heal everything from baldness to blindness, and often used for entertainment, without any form of protection, with dire results.



X-rays were once thought to cure baldness. Now we know they're more likely to cause it

ISTOCK

A couple of the later chapters on brain waves and ray guns seem surplus to requirements, while the chapter on solar eclipses is more concerned with dates and locations than the science.

As an astronomer I would have preferred some pages devoted to the space observatories that use each of the specific wavelengths to explore our cosmos and the different aspects each can reveal when focussed on a celestial object. I also feel more could have been said about the problem of light pollution, but these are just personal niggles. Overall this is a fascinating and entertaining book for anyone curious about the seen and unseen world of electromagnetism.

★★★★☆

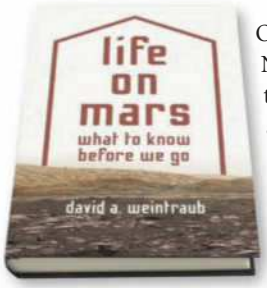
JENNY WINDER *is a freelance science writer, astronomer and broadcaster*

Zapped FACTS
Did you know?

- At least a quadrillion ultraviolet waves flash past you every second.
- 10 minutes in strong sunlight creates as much vitamin D as you'd get from drinking two hundred glasses of milk.
- If you could travel at 99.9999999 per cent of the speed of light, more than 223 centuries would elapse back on Earth during just one year of your life.
- In 1974 a message was sent to the star cluster M13 announcing our position in space. If any aliens there respond promptly, we'll receive their reply some time around the year 52,000.
- The longest radio waves measure around 1,600km from crest to crest.
- When you feel the warmth of the Sun, you are actually feeling increased vibrations of your skin's atoms.
- The Universe was born with all the energy it will ever have – as it can never be created or destroyed.
- Distant collapsing supermassive black holes emit more energy per second than the Sun gives off in its entire lifetime.
- When the Universe was half its current age, it was twice as hot as it is now.
- A vacuum can never truly exist as space (to a certain degree) will always be penetrated by heat: either via infrared radiation or microwaves.
- The microwave was discovered by accident in 1945, when Percy Spencer decided to investigate the phenomena that caused his chocolate bar to melt.

Life On Mars
What to Know Before We Go

David A Weintraub
Princeton University Press
£24.00 ● HB



On 5 May 2018, NASA launched the Mars InSight spacecraft, due to land on the Martian surface in late November. It is just one mission of many conducted over the past 60 years to increase our understanding of the Red Planet. Martian fascination has dominated our cultural consciousness since the planet was first observed by Galileo Galilei around 1610, and is the focus of David A Weintraub's latest book.

Weintraub details over 400 years of astronomical and scientific pursuit, searching for Martians, water, methane, lichen or algae, the probes and space missions, the debates and disagreements over data discrepancy and relevance. There are some great stories shared, most notably the discovery of meteorite ALH 84001 in 1984 in the Antarctic, thought to have originated from Mars, and the ensuing frenzy of scientific interest in the sample. The book is a comprehensive review of Mars, and while Weintraub hints at the moral dilemma facing scientists as they embark on the final stages of Mars exploration, further discussion is warranted, such as the ramifications of inadvertently contaminating a planet in our quest for answers. With a more balanced argument, perhaps we might be better informed of what we need to know before we go, as proposed in the book title.

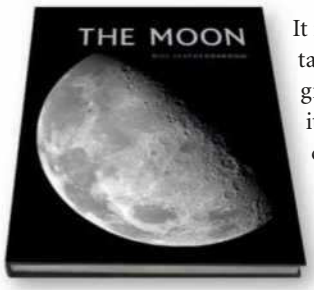
It seems that the jury is still out on whether life exists on Mars and the relentless search continues. Weintraub wisely leaves the last word to Carl Sagan: "If there is life on Mars… Mars then belongs to the Martians, even if the Martians are only microbes." Well worth the read.

★★★★☆

NIAMH SHAW *is an engineer, lecturer and science communicator*

The Moon

Bill Leatherbarrow
Reaktion
£25 ● HB



It is far too easy to take the Moon for granted, because it's such a regular, commonplace feature of the night sky. Some stargazers may curse its brightness, which drowns out the more delicate objects in the heavens, but Earth's constant companion is also the only world that we can observe close up, with waterless seas, or maria, visible even to the naked eye.

Bill Leatherbarrow, a former President of the British Astronomical Association, has written a highly readable account of the Moon and humanity's relationship with it. He begins with its impact on culture and religion, and how it was once even thought to provoke madness, giving rise to the term 'lunacy'.

We learn how the 'man in the Moon' features visible with the naked eye were thought to be a reflected image of Earth's own landscape, but that the first telescopic observations revealed that the Moon had a rugged terrain of its own.

Maps drawn with increasing levels of detail showed that the Moon's territory was as worthy of exploration as remote regions of our own planet. With the coming of the Space Age and visits by Apollo astronauts, the Moon was at last explored for real.

Leatherbarrow describes how readers can observe the Moon for themselves, from simple sketching to photography, including snapshots with a mobile phone. Various types of lunar features, including the maria, craters, ridges, rilles and rays, are listed. Surprisingly, the phenomenon of a lunar eclipse, a particularly special time to observe the Moon, is dealt with only briefly.

This is a simple, introductory guide to the Moon, squarely aimed at the beginner, with plenty of references and links to further reading and resources for those wanting to know more.

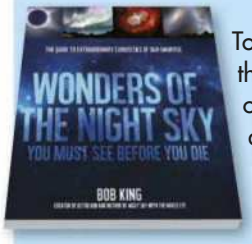
★★★★☆

PAUL SUTHERLAND *is a space writer and journalist*

Wonders of the Night Sky You Must See Before You Die

BOOK OF THE MONTH

Bob King
Page Street Publishing
£17.99 ● PB



To a beginner, the night sky can seem like a daunting place and it's all too easy to feel overwhelmed. This book, written by experienced astronomer and blogger Bob King, provides a clear guide to a wide range of the most interesting objects that are easily accessible either by naked eye, binoculars or a small telescope. It's structured around a 'bucket list' of 57 night-time wonders (natural and man-made) chosen by the author, who explains the visual and scientific interest of each and gives advice on how best to view it.

King's writing is friendly and assured and his expertise shines as brightly as the full Moon. Around half of the list are bodies within the Solar System, but the range extends from the International Space Station out to the galaxy group M81/M82.

The book is aimed at an American audience, so British readers will find it trickier to see some of the listed objects that are only visible here during our short summer nights or from more southern latitudes. The epilogue is a touching tribute to King's pet dog, whose insistence on being walked at night led to the author discovering so many astronomical sights and musing on the nature of canine time versus cosmological time.

Of course, any bucket list is subjective, but this one showcases objects that present a variety of astronomical phenomena and is persuasive in its enthusiasm.

★★★★☆

PIPPA GOLDSCHMIDT *is an astronomy and science writer*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1 TeleVue Type II UHC filter

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www.widescreen-centre.co.uk

Bring out the details in nebulae with these UHC filters. Specially designed to ensure consistency across the filter, they come in 1.25-inch and 2-inch sizes.

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+49 (0)8999 228750 • www.teleskop-express.de

This focuser is only 60mm high, meaning you don't lose much of the valuable optical path and create problems with the focal position. The friction screws will keep their position even when there's a high load.

3 Bhatinov mask lens cover

Price $88 • **Supplier** William Optics
www.williamoptics.com

With these uniquely designed lens covers you can keep your telescope dust free in storage, then pop off the cap to reveal a Bhatinov mask ensuring your stars are in perfect focus.

4 ZWO 60mm guidescope with double base

Price £87.60 • **Supplier** 365 Astronomy
020 3384 5187 • www.365astronomy.com

This finderscope has a double base to fit both Vixen-style and narrower dovetail bars. It can also double as a telephoto lens for a DSLR (camera specific adaptors not included).

5 Touchscreen gloves

Price £22.50 • **Supplier** Blacks
01613 937059 • www.blacks.co.uk

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6 Sundial compass

Price £60 • **Supplier** Green Witch
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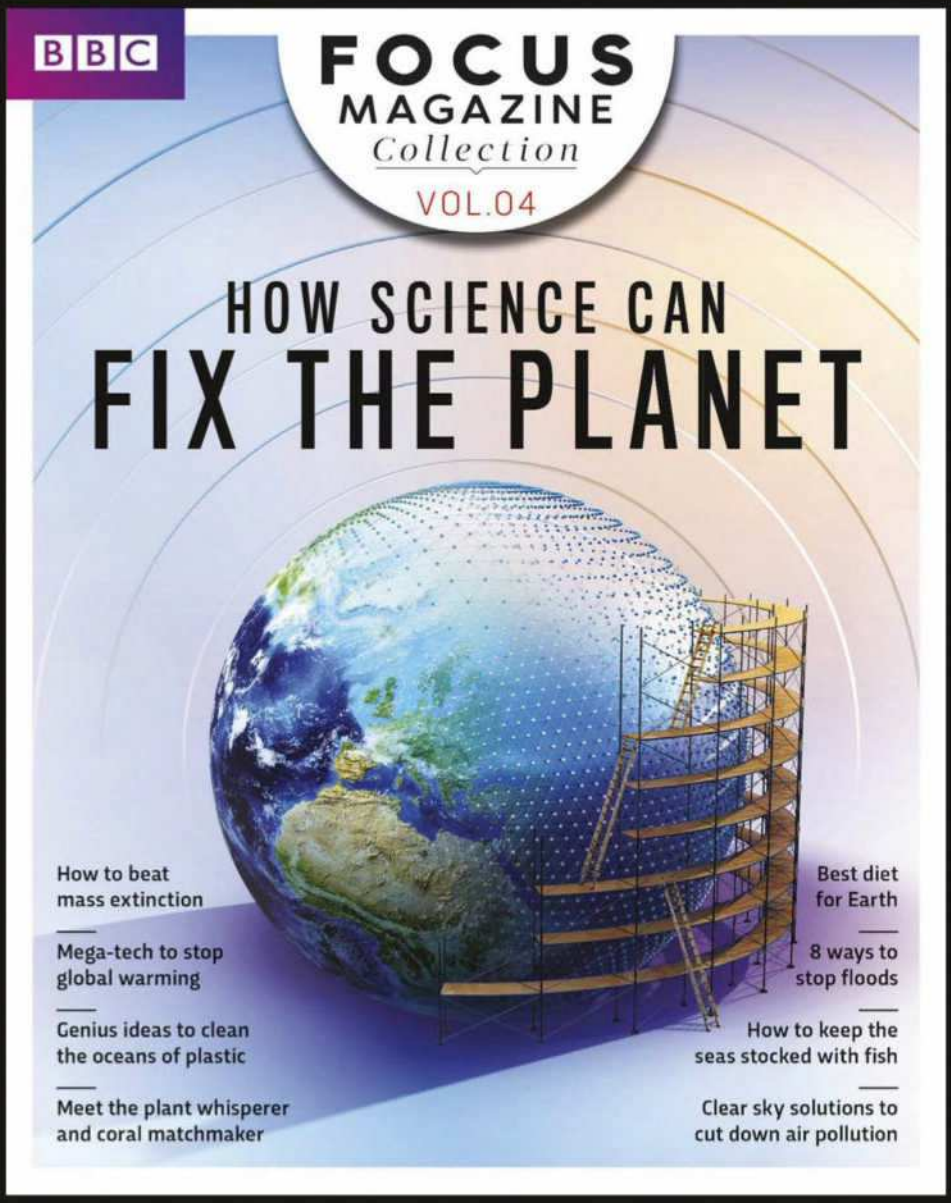

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WHAT I REALLY WANT TO KNOW IS...

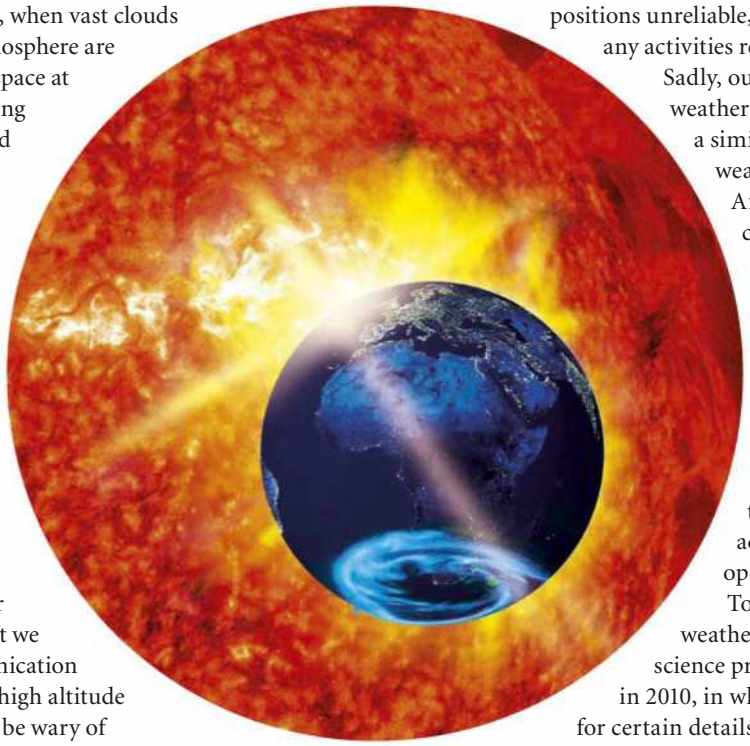
How can we defend against solar storms?

Professor Christopher Scott is looking for ways to predict oncoming solar storms so that we can keep Earth safe

INTERVIEWED BY ELIZABETH PEARSON

The primary danger we face from the Sun is when it sporadically erupts in what's known as a coronal mass ejection (CME), when vast clouds of the solar atmosphere are propelled into space at around two million km/h, taking some of the Sun's magnetic field with it. CMEs that reach Earth interfere with our magnetic fields. This is a real concern in a modern world so reliant on electricity (see feature on page 30). Extreme eruptions, which occur once every 100 years or so, have the potential to overload networks and cause transformers to fail, and in those areas we would lose the ability to refrigerate food and medicine; to pump fuel; to communicate. Even small solar storms can affect the spacecraft we rely on for navigation, communication and security. Aircraft flying at high altitude or across the poles also have to be wary of continued exposure to increased radiation.

The UK government has recognised the risk of a major solar event hitting Earth as about equivalent of a flu pandemic: it's going to happen once every century or so and the consequences are far reaching.



You know how bad weather can make your television picture break up? Well, that's just peanuts compared to bad *space* weather

Space weather forecasting

People who work in the worst-affected industries tend to be aware of the issue, but the average person watching television doesn't know about the work being done to keep TV satellites transmitting. A recent YouGov poll showed that 97 per cent of the population knows little or nothing about space weather. It's understandable – most people have never experienced a solar storm, and if they have it's in the form of a beautiful aurora. But as technology advances, we become more vulnerable.

If we knew a storm was coming, though, we could mitigate the damage. Satellite operators could power down high voltage components or choose not to upload some new satellite software. Power companies could open up every single wire they've got on their grid to spread the current out and stop any one part being overloaded. Aircraft could be diverted away from the poles, or fly at lower altitudes (though that uses more fuel). Also, solar storms tend to make GPS positions unreliable, so you might want to delay any activities reliant on the system.

Sadly, our ability to forecast space weather is lacking; currently it's in a similar place to terrestrial weather forecasting in the 1950s. After a storm has erupted we can show where and when it erupted, and use that information to predict the chance of the storm hitting Earth a few hours in advance. But aircraft operators need the best part of a day to rearrange flights and satellite operators say that current forecasts aren't accurate enough to make real operational decisions.

To learn more about solar weather, we launched a citizen science project called Solar Stormwatch in 2010, in which 20,000 volunteers looked for certain details in images taken by the twin spacecraft of the Solar Terrestrial Relations Observatory (STEREO), so that we could gain a better understanding of how the storms move and at what speed. We're now applying everything we learned to upcoming weather satellites.

There's also a new mission due to launch in July called the Parker Solar Probe (see page 37) which will fly into the Sun's atmosphere and look at the solar magnetic atmosphere close up to find out what is triggering the CMEs in the first place. Another upcoming mission, the Solar Orbiter, will put a spacecraft in orbit over the Sun's poles, looking at the magnetic field there. We've never done that before. That's due to launch in February 2019.

In the meantime, we've relaunched Solar Stormwatch to help us understand how clouds change as they are carried by the solar wind. Another activity, launched in conjunction with a new exhibit on the Sun at Science Museum London asks volunteers to decide how complex storms appear. All of these activities combined should help us improve our forecasts of when solar storms will arrive at Earth.

ABOUT PROFESSOR CHRISTOPHER SCOTT

Christopher Scott is a space and atmospheric physicist from the University of Reading, who works with the citizen science project Solar Stormwatch. Visit www.solarstormwatch.com to take part

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THE SOUTHERN HEMISPHERE IN JULY

With Glenn Dawes

WHEN TO USE THIS CHART

1 JUL AT 00:00 UT
15 JUL AT 23:00 UT
30 JUL AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as the stars crossing it set four minutes earlier each night. We've drawn the chart for latitude –35° south.

JULY HIGHLIGHTS

Mars is at opposition this month, giving us our best views since August 2003. For July and August the Martian disc will be greater than 20 arcseconds, peaking at 24 minutes on 27 July, when even small telescopes will give good views of its southern polar ice cap and the features associated with plains, valleys and mountains. Its negative declination ensures observers in the Southern Hemisphere see the Red Planet culminate high in the sky, minimising atmospheric

STARS AND CONSTELLATIONS

The constellation of Lyra, the Harp, is low in the northern sky. It consists of four 3rd and 4th magnitude stars arranged in a narrow parallelogram with its brilliant naked-eye alpha star, Vega, a couple of degrees southwest. As well as being the fifth brightest star in the sky (mag. 0.0), Vega is also the closest bright star to the solar apex (9° to the south). This is the position in the sky the Sun is currently heading towards as it continues its 230 million year orbit of the Milky Way.

THE PLANETS

In July all five naked-eye planets are visible in the early evening. Starting in the west-northwest, Mercury has one of its best evening returns, setting just after the end of twilight for most of the month (don't confuse it with the nearby star, Regulus). Directly above is the beacon of Venus, with brilliant Jupiter due north in Libra. Turning to the east you'll find Saturn near the lid star of Sagittarius's Teapot. Finally, luminous Mars, which for a few months is outshining Jupiter, is rising in Capricornus.

DEEP-SKY OBJECTS

This month we visit Ophiuchus, the Serpent Bearer. IC 4665 (RA 17h 46.3m, Dec +5° 43') is a large bright (mag. +4.2) open star cluster comprising around 30 stars ranging from 7th to 9th magnitude. Spanning 1° of sky, its members are well scattered, looking great in binoculars sitting beside Beta Ophiuchi (1° away). This mag +2.8 star helps make up the large 'Coffin' asterism.

Inside this casket are two globular clusters visible as fuzzy stars in the same binocular field, NGC 6254 or M10, pictured, (RA 16h 57.1m, Dec. -4° 06') and 3° to its northwest, NGC 6218 (M12). They are of similar brightness with vivid central cores. An interesting difference is that M12's halo is much more loosely packed than M10's with stars (mag. +12) well resolved, even close to the core.

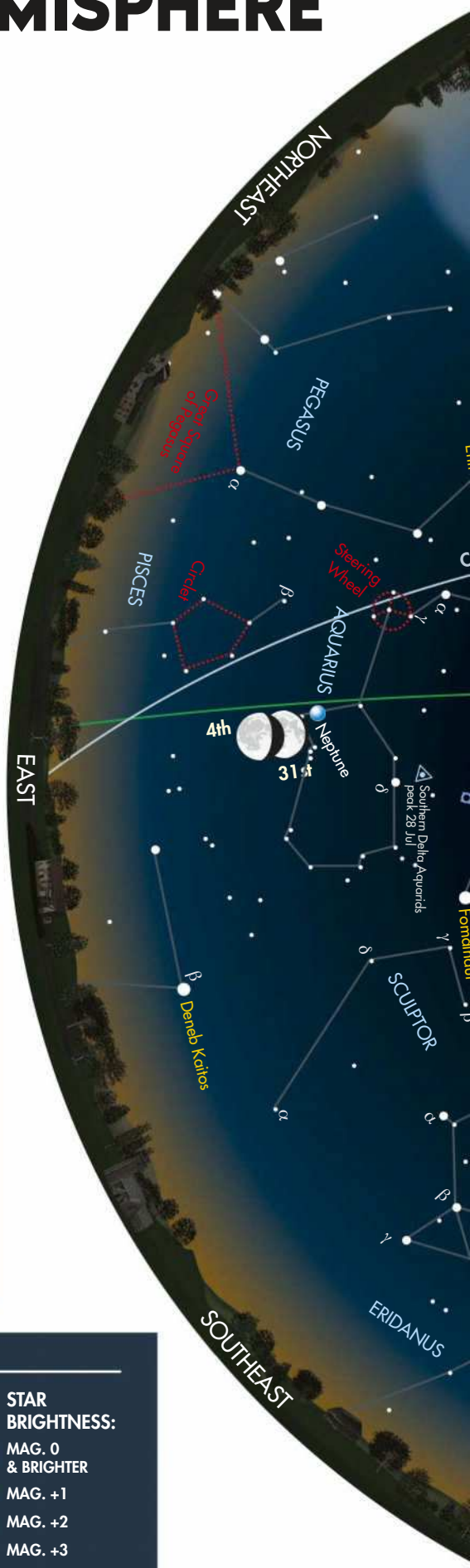
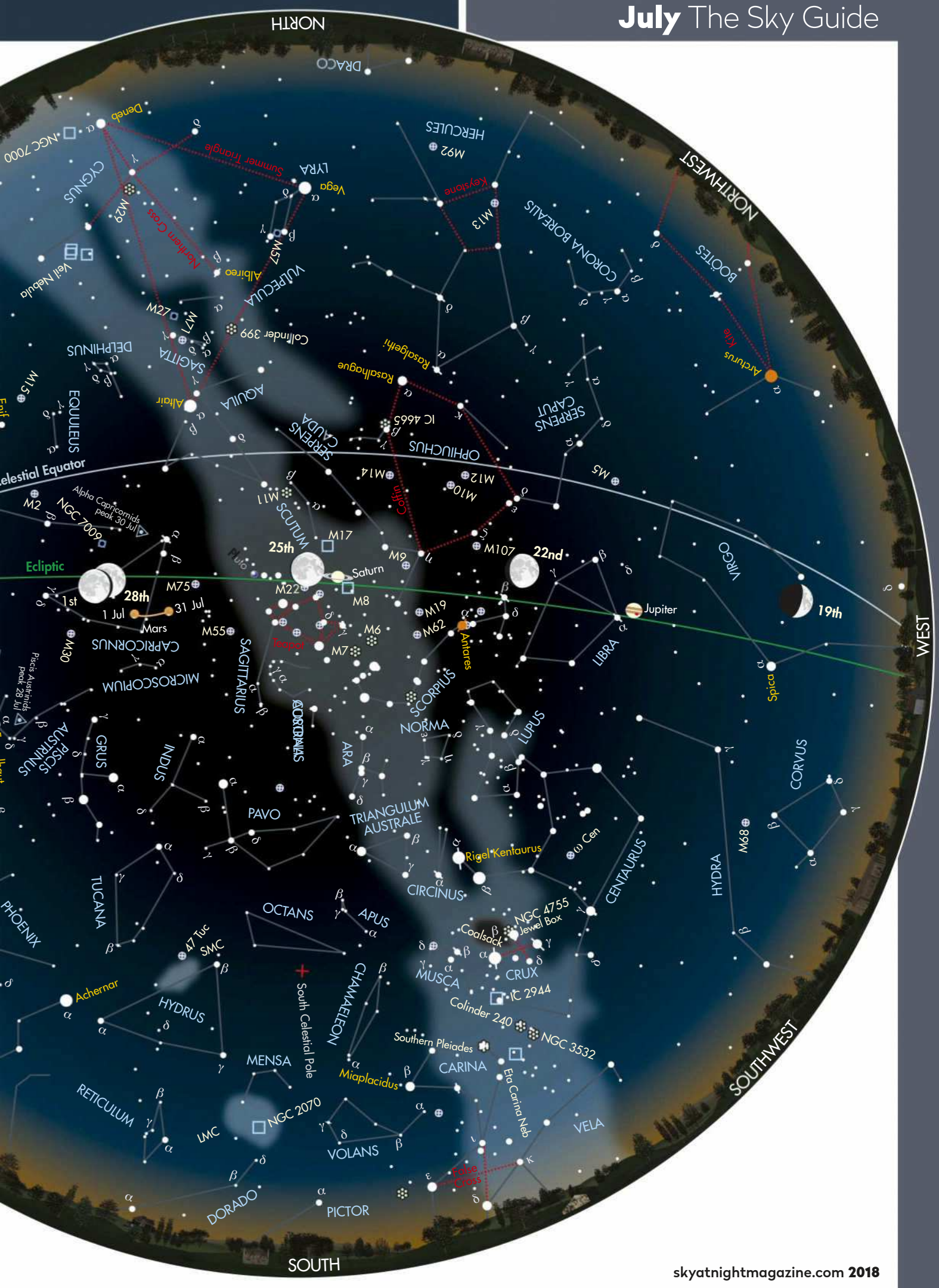


CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE, IMAGE: BERNHARD HUBL/CCDGUIDE.COM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NORTHWEST
WEST
SOUTHWEST
SOUTH
Celestial Equator
Ecliptic
DRACO
HERCULES
M92
Keystone
M13
CORONA BOREALIS
BOÖTES
Arcturus
Kite
LYRA
Vega
Summer Triangle
Deneb
NGC 7000
CYGNUS
M29
Northern Cross
Albireo
M57
Veil Nebula
VULPECULA
Collinder 399
M27
M71
SAGITTA
DELPHINUS
Altair
AQUILA
Rasalgethi
Rasalhague
IC 4665
OPHIUCHUS
SERPENS CAPUT
SERPENS CAUDA
Coffin
M14
M12
M10
M5
M3
EQUULEUS
M15
Enif
M2
NGC 7009
Alpha Capricornids peak 30 Jul
M11
SCUTUM
M17
25th
Saturn
M9
M107
22nd
VIRGO
M75
28th
1st
1 Jul
31 Jul
Mars
M22
M8
M19
M62
M6
M7
Teapot
Antares
Jupiter
19th
Spica
LIBRA
M55
M30
CAPRICORNUS
MICROSCOPIUM
SAGITTARIUS
SCORPIUS
NORMA
LUPUS
Piscis Austrinids peak 28 Jul
PISCIS AUSTRINUS
GRUS
INDUS
ARA
TRIANGULUM AUSTRALE
PAVO
Rigel Kentaurus
ω Cen
CENTAURUS
CIRCINUS
CORVUS
HYDRA
M68
TUCANA
PHOENIX
OCTANS
APUS
47 Tuc
SMC
Coalsack
NGC 4755 Jewel Box
CRUX
MUSCA
IC 2944
Colinder 240
NGC 3532
Achernar
HYDRUS
South Celestial Pole
CHAMAELEON
Southern Pleiades
CARINA
Eta Carina Neb
VELA
MENSA
Miaplacidus
RETICULUM
LMC
NGC 2070
VOLANS
False Cross
DORADO
PICTOR

Sky-Watcher®

Performance, Precision and Value

Sky-Watcher is a First-Class telescope brand offering an incredible range of high-quality astronomical telescopes and accessories, catering for users of all age groups and abilities, from the novice right up to the serious advanced astronomer. Sky-Watcher astronomical telescopes perfectly integrate modern optical technology with precision mechanical engineering, resulting in designs of suberb functionality, versatility and uncompromising levels of performance.

EXPLORER-130 & EXPLORER-130M 130mm (5.1") F/900 NEWTONIAN REFLECTOR TELESCOPES

- Magnifications (with optics supplied): x36, x72, x90, x180 • Highest Practical Power (Potential): x260 • Diameter of Primary Mirror: 130mm
- Telescope Focal Length: 900mm (f/6.92) • Eyepieces Supplied (1.25"): 10mm & 25mm • x2 Barlow Lens • 30% more Light Gathering than 114mm
- R.A. Motor Drive With Multi-Speed Handset (Explorer-130M only) • Red Dot Finder • EQ2 Equatorial Mount • Aluminium Tripod with Accessory Tray

Sky at Night GROUP TEST WINNER

Explorer-130 Model

EXPLORER-130
(Without R.A. Motor Drive)
Prod.Code 10922

SRP £189

EXPLORER-130M
(With R.A. Motor Drive)
Prod.Code 10713

SRP £229

Explorer-130M Model illustrated

"Every class of object we viewed could be seen clearly… Taking everything into account, this telescope made observing the night sky enjoyable… great views coupled with ease of use."
BBC Sky at Night Magazine

PARABOLIC REFLECTORS – PREMIUM FEATURES

Both the SKYHAWK-1145P & EXPLORER-130P models below offer excellent all-round performance on The Moon, Planets & Deep Sky Objects. They feature premium quality Parabolic Primary Mirrors to eliminate spherical aberrations, producing even sharper, higher-contrast images which are full of detail. A "Paraboloidal" mirror is ground to a complex shape which brings all incoming light rays to a perfect focus, on axis. In addition they feature 0.5mm Ultra-Thin secondary mirror supports, to reduce diffraction spikes and light loss.

SKYHAWK-1145P 114mm (4.5") F/500 PARABOLIC NEWTONIAN REFLECTOR TELESCOPE

- Magnifications (with optics supplied): x20, x40, x50, x100
- Highest Practical Power (Potential): x228
- Diameter of Primary Mirror: 114mm
- Telescope Focal Length: 500mm (f/5)
- Eyepieces Supplied (1.25"): 10mm & 25mm
- x2 Barlow Lens • Parabolic Primary Mirror
- 0.5mm Ultra-Thin Secondary Mirror Supports
- Red Dot Finder
- EQ1 Equatorial Mount
- Aluminium Tripod with Accessory Tray
- 125% more Light Gathering than 76mm

Sky at Night GROUP TEST WINNER

Prod.Code 10709

SRP £159

"The optics were so good... Captures star clusters and brighter nebulae beautifully... The planet (Saturn) was jaw-droppingly beautiful, with a host of fine detail visible... The review instrument certainly delivered in every important respect."
BBC Sky at Night Magazine

EXPLORER-130P 130mm (5.1") F/650 PARABOLIC NEWTONIAN REFLECTOR TELESCOPE

- Magnifications (with optics supplied): x26 & x65
- Highest Practical Power (Potential): x260
- Diameter of Primary Mirror: 130mm
- Telescope Focal Length: 650mm (f/5)
- Eyepieces Supplied (1.25"): 10mm & 25mm
- Parabolic Primary Mirror
- 0.5mm Ultra-Thin Secondary Mirror Supports
- Red Dot Finder • EQ2 Equatorial Mount
- Aluminium Tripod with Accessory Tray
- 30% more Light Gathering than 114mm

Astronomy HOT Product

Prod.Code 10712

SRP £229

"I was most impressed by the views revealed by the 'scope during tests… Despite a phase of nearly 96 percent, the waxing gibbous Moon revealed a seemingly inexhaustible amount of fine detail... Highly recommended!"
Astronomy Now Magazine

Sir Patrick Moore Endorsed Sky-Watcher Telescopes

"I have used a great number of telescopes; some are good, some mediocre and some bad. To me the Sky-Watcher range of instruments are very good indeed, & suited to amateurs of all kinds - and they are not priced out of the market! Excellent value. Use them and enjoy them."
Sir Patrick Moore CBE FRS (1923-2012)

76 page Full Colour Catalogue

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